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CATALOGUE

OF THE

FOSSIL FISHES

IN THE

BRITISH MUSEUM

(NATURAL HISTORY),

CROMWELL ROAD, S.W.

PART II.

CONTAINING THE

ELASMOBRANCHII (ACANTHODII), HOLOCEPHALI, ICHTHYODORULITES, OSTRACODERMI, DIPNOI, AND TELEOSTOMI (CROSSOPTERYGII AND CHONDROSTEAN ACTINOPTERYGII).

Smithsonian Institution
266503
C Gill
National Museum.

BY

ARTHUR SMITH WOODWARD,
F.G.S., F.Z.S.

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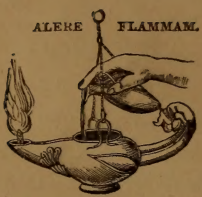

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PREFACE.

Since the completion of Part I. of this Catalogue in 1889, nearly two years have elapsed, during which time great progress has been made in the examination and careful study of the Collection of Fossil Fishes; while Mr. Arthur Smith Woodward has had the additional advantage of visiting the principal Museums of Scandinavia, Russia, Austria, Germany, the United States, and Canada. A knowledge of the "types" contained in other Museums is essential to a correct interpretation of our own specimens, and much of the merit of the present volume may be attributed to this fact, and to the wider experience gained by personal interchange of views with ichthyologists abroad.

Special attention has also been paid by the author to the careful collation of the very extensive and widely scattered literature of his subject, as amply testified by the very copious references which occur throughout this Catalogue.

The present volume commences with the *Acanthodii*, which are shown, by preponderating evidence, to belong to the Elasmobranchs. The *Chimæroidei* come next, the most important forms being those of *Squaloraja* and *Myriacanthus*; while *Ischyodus* and *Edaphodon* are represented by a fine series of jaws. Next follows the very large collection of "Ichthyodorulites" (fish-spines) belonging to Elasmobranch and Chimæroid fishes, but not definitely placed in any group. To these succeed the Ostracodermi, notochordal fishes with a well-developed exoskeleton, the head and anterior portion of

the trunk being covered with plates, and the mouth being destitute of hard parts. Here are placed the earliest-known fossil fishes, the anomalous *Pteraspidæ* and *Cephalaspidæ*, of which the finest examples have recently been presented by George H. Piper, Esq., F.G.S., of Ledbury. These are succeeded by the *Asterolepidæ* (well represented by *Pterichthys*, *Bothriolepis*, &c.). Then follow the Dipnoi, represented by *Dipterus*, *Palædaphus*, *Phaneropleuron*, *Ctenodus*, *Ceratodus*, &c.; and the *Arthrodira*, proposed to embrace the unrivalled collection of *Coccosteus*, with *Dinichthys*, *Homosteus*, *Heterosteus*, &c.

The Crossopterygian Teleostomi come next, with *Holoptychius*, *Rhizodus*, *Megalichthys*, *Glyptopomus*, and *Cœlacanthus*, with *Undina*, *Macropoma*, and many others. To these succeed Actinopterygii of the family *Palæoniscidæ*, with *Oxygnathus* and some twenty-five other genera, one of the largest groups represented in this Catalogue, and to the determination of which Dr. Traquair has devoted so many years of study. The *Platysomatidæ* conclude the present volume, with the fine series of *Platysomus*, *Eurynotus*, *Cheirodus*, &c., from the Permian and Carboniferous strata.

It is hoped that the sixteen Plates and fifty-eight woodcuts will prove of assistance to those using the Catalogue, especially at a distance from the Museum Collection, and also enable the student in Comparative Ichthyology the better to appreciate the points of structure indicated in the text.

The next volume will contain the modern Chondrostean Actinopterygii, and the lengthy series of typical Physostomous fishes specially characteristic of the Mesozoic and early Tertiary Epochs.

HENRY WOODWARD.

British Museum,
Geological Department.
January 20th, 1891.

INTRODUCTION.

There is no more striking instance of the difficulty of interpreting fossil remains by a close comparison with the skeletons of existing animals, than that presented by the Palæozoic Fishes. When the first fragments of Coccostean plates from the Lower Old Red Sandstone of Caithness were noticed by Sedgwick and Murchison sixty years ago, nothing more closely similar among existing animals could be found than the dermal plates of the mud-tortoises. *Trionyx* was accordingly entered in the list of Caithness fossils[1]. Nearly eight years later, the Russian geologist Kutorga[2], when attempting to interpret fragmentary teeth and dermal plates from the corresponding formations of Livonia, was led to name a long series of mud-tortoises, lizards, and Ichthyosauri from that country, giving good figures and detailed descriptions of the evidence upon which the restoration of so remarkable and unexpected a fauna was based. Even when such entirely erroneous impressions were removed by the discovery of more satisfactory specimens, and when the far-reaching researches of the ichthyologist, Louis Agassiz, had shown that all these remains pertained to fish-like organisms no longer existing, the same tendency to interpret the past by a rigorous comparison with the present everywhere prevailed, and the frequent result was a distortion of the facts of structure in the fossils to conform to arrangements observed in the present fish-fauna. Not only was Hugh Miller induced, by Agassiz's researches, to compare in detail the skulls of some of the Old Red genera with that of the living cod-fish[3], but this recent gadoid was actually used by Agassiz

[1] Trans. Geol. Soc. [2] vol. iii. (1829), p. 144, pl. xvi. fig. 6.

[2] S. Kutorga, 'Zweiter Beitrag zur Geognosie und Paläontologie Dorpat's,' 1837.

[3] H. Miller, 'Footprints of the Creator,' (1849), p. 48.

himself to impart a life-like aspect to the head in his restored figure of the Dipnoan and Crossopterygian genera *Dipterus* and *Diplopterus* [1]. In the interpretation of fins, again, close comparison with existing fishes led to some noteworthy fundamental errors, such as the restoration of the dorsal fin of *Coccosteus* [2], as if it pertained to the most modern specialized type; and many other cases might be cited of an essentially similar character. Quite in modern times, indeed, the reiterated association of the Cephalaspidæ, Asterolepidæ, and Coccosteidæ with recent Sturgeons by Owen [3]; the still more elaborate comparison of the Coccosteidæ with existing Siluroids by Huxley [4]; and the quite recent adhesion to this Siluroid theory by Newberry [5]—all must now be regarded as resulting from too narrow a conception of the limits within which certain minor skeletal characters may occur. The ascertained facts of embryology and the well-established broad principles of palæontology are now at the disposal of the investigator; and it is hoped that a detailed review of the whole subject, such as is attempted for the first time in the present volume, may tend towards a more philosophical understanding of the early representatives of the class under consideration.

The first essential fact requiring special emphasis, at the outset, seems to be, that although the Palæozoic fishes certainly belong to the most generalized great divisions of their class, a large proportion of the known types are extremely specialized members of these divisions. This is clearly indicated by the characters of the fins in many forms. Just as in the existing fauna, the most striking examples of extreme specialization are comprised within the dominant higher groups of Actinopterygian Teleostomi, so in the Palæozoic fauna the same instances of development occur almost exclusively in the then dominant orders of the Ostracodermi, Elasmobranchii, and Crossopterygian Teleostomi. If in the one case specialization proceeds sometimes almost exactly in the same manner as it does in the other, everything seems to point to the conclusion that this is

[1] L. Agassiz, 'Poissons Fossiles du Vieux Grès Rouge,' (1844), pl. E.

[2] L. Agassiz, *ibid.* pl. vi. fig. 3.

[3] R. Owen, 'Palæontology,' ed. 2 (1861), p. 139; and 'Anatomy of Vertebrates,' vol. i. (1866), p. 12.

[4] T. H. Huxley, "Preliminary Essay upon the Systematic Arrangement of the Fishes of the Devonian Epoch" (Mem. Geol. Surv. dec. x. 1861), p. 29.

[5] J. S. Newberry, "The Palæozoic Fishes of North America" (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 141, *et passim*.

merely an instance of parallel development in the different groups; the same laws prevailing in each great division and producing analogous results.

Such being the case, the difficult question arises as to what characters determine the Subclasses (as we prefer to term the great divisions), according to the most recent researches. For a long period, as is well known, it has been a prevalent custom, at least in Europe, to follow the combined arrangements of Cuvier and Agassiz as modified by Johannes Müller[1]. Sharks and Rays, with the Chimæras, have been generally regarded as an order or subclass, variously termed Elasmobranchii, Chondropterygii, Selachii, or Placoidei, and specially characterized (i) by the absence of membrane-bones or true ossifications of any kind, (ii) by the arrangement of the gills, and (iii) by the characters of the brain, heart, intestine, and ovaries. The recent *Polypterus*, *Acipenser*, *Lepidosteus*, and *Amia* have been regarded as typifying four groups, to be comprised in an order or subclass Ganoidei; this agreeing with the Elasmobranchii in the more important visceral characters, though distinguished by the presence of an air-bladder, the small size of the numerous ova, and the development of both endoskeletal and exoskeletal ossifications, including a bony gill-cover. The Dipnoi, typified by the existing *Lepidosiren*, *Protopterus*, and *Ceratodus*, have sometimes been included in the Ganoidei, sometimes (as by Müller) elevated into an equivalent division, on account of their approach to the Amphibia; while the Teleostei, or modern bony fishes, with decussating optic nerves, no intestinal spiral valve, and a non-contractile bulbus arteriosus to the heart, have constituted the highest order or subclass, specially characteristic of the existing fauna. Dr. Günther[2] proceeds further than all the other authors in elaborating this scheme of classification, uniting the Elasmobranchii and Ganoidei (including the Dipnoi) in a great subclass of Palæichthyes; this to be equivalent in value to the Teleostei, and distinguished solely by the three visceral characters already mentioned in connection with the heart, intestine, and optic nerves. To emphasize the division all the more clearly, the "Palæichthyes"

[1] J. Müller, "Ueber den Bau und die Grenzen der Ganoiden und über das natürliche System der Fische," Abh. k. Akad. Wiss., phys. Cl., Berlin, 1844, pp. 117–216, with plates.

[2] A. Günther, Phil. Trans. 1871, p. 554; also 'An Introduction to the Study of Fishes' (1880).

are arranged in ascending series, so far as can be determined, while the "Teleostei" are treated in precisely the opposite order.

This dual subdivision may appear, at first sight, to be the logical result of Agassiz's recognition of the primitive nature of the typical "Ganoidei,"—especially when added to Müller's subsequent discovery of the important characters these fishes possess in common with the Elasmobranchs, Chimæroids, and Dipnoans. A consideration of the researches of Agassiz himself, however, suffices to demonstrate that if gradations in skeletal anatomy are more or less concomitant, as usual, with the evolution of the soft parts, every essential link between the "Ganoidei" and "Teleostei" is already known. So long ago as 1866, this fact was clearly recognized by Owen[1], when he proposed to group the Ganoids and Teleosteans in a subclass Teleostomi, adopting the Plagiostomi (including Holocephali) and Dipnoi as equivalent divisions. About the same time, Kner[2] concluded that the group of Ganoidei was not homogeneous, and was, at least in part, separated too widely from the Teleosteans by Agassiz. The subsequent investigations of Cope[3], Gill[4], Lütken[5], and Huxley[6] have tended in the same direction; and the most recent statements of the last-named author concerning points of visceral anatomy will be generally regarded as final and conclusive. The researches of Boas are cited to prove that there is no absolute distinction between Ganoids and Teleosteans in the conus arteriosus of the heart; the rudiment of a spiral valve in the intestine of *Chirocentrus* is noticed as rendering a second point of the original Müllerian diagnosis invalid; while a reference to Wiedersheim's discovery of the partial decussation of the fibres of the optic nerves in some lizards, suggests that if this feature be of little systematic importance in an order of Reptiles, it is not likely to be

[1] R. Owen, 'Anatomy of Vertebrates,' vol. i. (1866), p. 7.

[2] R. Kner, Sitzungsb. k. Akad. Wiss., math.-naturw. Cl. vol. liv. pt. i. (1866), pp. 519–536.

[3] E. D. Cope, Trans. Amer. Phil. Soc., n. s., vol. xiv. (1871), pp. 445–460; Proc. Amer. Assoc. Adv. Sci. 1871 (1872), pp. 317–343; Amer. Nat. vol. xix. (1885), pp. 234–243; *ibid.* vol. xx. (1886), p. 1031; *ibid.* vol. xxi. (1887), pp. 1014–1019; *ibid.* vol. xxiii. (1889), pp. 852–860; Proc. Amer. Phil. Soc. 1884, pp. 577–585.

[4] T. Gill, Proc. Acad. Nat. Sci. Philad. 1861, pp. 12–20; and "Arrangement of the Families of Fishes," Smithsonian Miscell. Coll. vol. xi. (1872).

[5] C. Lütken, "Ueber die Begrenzung und Eintheilung der Ganoiden," Palæontographica, vol. xxii. (1873), p. 1; translated from Videnskab. Meddel. Naturh. Foren. Kjöbenhavn, 1868.

[6] See especially Proc. Zool. Soc. 1876, pp. 24–59, and *ibid.* 1883, pp. 137–139.

an essential character in the diagnosis of subclasses of Fishes. In short, the terms "Ganoid" and "Teleostean," while convenient for use in alluding to well-defined bony-scaled types and modern bony fishes respectively, can no longer be employed as means of precise scientific expression.

At the same time, however, that modern research has led to these difficulties, the combined results of comparative anatomy and palæontology have suggested an alternative classification, which seems to express all the more important facts at present known. It is to be expected that any subdivision of a class into "orders" or "subclasses" will gradually become less cogent as the earlier types are more fully revealed; but when all discoveries tend to prove that these subdivisions are divergent phyla, meeting only in remote antiquity, an approximately natural classification seems to have been attained. Among fishes, for example, it is now well known that, at least since Lower Devonian times, there have been two distinct plans of cranial structure, between which no definitely intermediate forms occur. As pointed out both by Stannius [1] and Huxley [2], the upper segments of the mandibular and hyoid arches are directly fused with the chondrocranium in *Chimæra*, *Protopterus*, and their allies; while they are loosely articulated, the upper segment of the hyoid arch forming a movable suspensorium, in all the Elasmobranchs and the so-called Ganoidei and Teleostei. These types of cranial structure are termed respectively the "autostylic" and "hyostylic" [3]. It is now generally admitted that the first division passes through some of the early Dipnoan fishes into the Amphibia, and thus into terrestrial Vertebrates; while it seems equally clear that the extreme specialization of the second division has resulted in the modern types of fishes—the vertebrates most completely adapted to an aquatic existence.

Again, it will be observed that in the earliest known Palæozoic fish-fauna there are representatives both of the autostylic and hyostylic types on the same primitive biological level, so far as the development of the appendicular skeleton and the axial skeleton of the trunk are concerned, but yet differing in the nature of the exoskeleton. Some families exhibit mere "placoid" dermal calcifications, traversed by delicate branching nutritive canals, these isolated plates not uniting even in the region of the branchial apparatus to form any covering of the clefts; other families are well encased in dermal and

[1] H. Stannius, 'Handbuch der Zootomie—Fische,' (1846), pp. 18, 32.
[2] T. H. Huxley, 'Elements of Comparative Anatomy' (1864), pp. 195, 209.
[3] T. H. Huxley, Proc. Zool. Soc. 1876, pp. 40, 41.

membrane-bones, which have a definite symmetrical arrangement, and consist, at least in their basal layer, of tissue with distinct lacunæ, these being often arranged in haversian systems. All palæontological evidence combines to indicate that both among the hyostylic and the autostylic fishes these two types of exoskeleton have characterized divergent or parallel phyla, exhibiting no connection since their origin; and, if the evolution of the paired fins be regarded as a criterion, three of these four types (*i. e.*, all except the bony hyostylic group) attained their maximum specialization before the end of the Palæozoic Epoch.

The evolution of the fins, indeed, and especially of the paired fins, is shown by Cope to be the most satisfactory and philosophical clue to the arrangement of all the minor groups of fishes. Just as the various modifications of the pentadactyl limb in the Ungulate Mammals—the vertebrates which eventually become most completely adapted for progression on land—afford the principal means of determining the natural subdivision of that order; so among the greater groups of fishes—the vertebrates that become specially adapted for progression in water—the successive modifications of the primitive fin-folds form the most obvious clue to the phases through which the various types have passed in the course of their specialization.

If, in accordance with the present teaching of embryological research, the paired limbs have developed from lateral folds, the primitive condition of these appendages still remains undiscovered, and their evolution can only be traced from a comparatively advanced stage. All the most generalized early Palæozoic fishes hitherto met with exhibit two pairs of limbs, of the paddle-like form termed "archipterygium" by Gegenbaur; and subsequent specialization has resulted in the gradual atrophy of these limbs, usually with a concomitant development of the fringing dermal rays (actinotrichia). Of the median azygous fin-fold almost the earliest stages are known, and in this case again specialization results, first in the subdivision and partial loss of the originally continuous fold, then in the development of the dermal rays and the gradual atrophy of the endoskeletal supports, and finally in the intimate correlation of these two series of elements. In the most primitive types, there is at least a double series of endoskeletal rods supporting the continuous fin, directly apposed to the neural and hæmal spines of the axial skeleton; in later types the appendicular elements gradually lose all connection with the segments of the

endoskeleton, and are correlated instead with the merely dermal developments in the fin-fold itself. Though not absolutely diagnostic, on account of intermediate conditions, the three principal stages in the development of the paired fins correspond closely to three ordinal groups; while the modifications of the median fins are of less value, sometimes not even diagnostic of divisions which other characters lead to be regarded as suborders.

Summarizing the present state of knowledge, the subclasses and orders of fishes of which the endoskeleton has been discovered may thus be arranged as in the table on page xii. Another subclass, that of Ostracodermi, also demands consideration in connection with Palæozoic Fishes, whether or not jaws and a paired appendicular skeleton eventually prove to be absent. All these divisions are defined in the Catalogue itself, and it thus suffices, by way of introduction, merely to justify some of the features in the arrangement adopted, and to particularly emphasize a few of the more important results.

ELASMOBRANCHII.

In the Introduction to the first part of the present Catalogue, published nearly two years ago, the chief known features in the palæontology of the typical Elasmobranch fishes were summarized and discussed; and subsequent contributions to the subject have been made by Döderlein[1], Koken[2], Fritsch[3], and Newberry[4]. The researches detailed in the following pages make still further additions to existing knowledge of the subclass; and it now seems possible to recognize a feature of considerable interest that has hitherto escaped adequate notice. This relates to the early specialization of the Elasmobranchii, and the extinction of all but the more generalized types before the end of the Palæozoic Epoch.

Such, at least, appears to be the most philosophical interpretation of the characters presented by the remarkable Palæozoic order of Acanthodii. Since the first detailed description of the typical genus, *Acanthodes*, by Roemer[5], it has been generally admitted that this order of fishes is closely connected with the Elasmobranchii by several important characters, and some authors (*e. g.* Lütken[6] and

[1] L. Döderlein, Zool. Anzeiger, vol. xii. (1889), pp. 123–127.
[2] E. Koken, Sitzungsb. Ges. naturf. Freunde Berlin, 1889, pp. 77–94.
[3] A. Fritsch, 'Fauna der Gaskohle,' vol. ii. pt. iv., vol. iii. pt. i. (1889–90).
[4] J. S. Newberry, 'Palæozoic Fishes N. America' (1889).
[5] F. Roemer, Zeitschr. deutsch. geol. Ges. vol. ix. (1857), pp. 65–83, pl. iii.
[6] C. Lütken, Palæontogr. vol. xxii. (1873), p. 41.

Scheme of SUBCLASSES *and* ORDERS *of the Class Pisces.*

Stages in Evolution of Paired Fins.	Hyostylic Fishes.		Autostylic Fishes.	
	I. ELASMOBRANCHII.	II. TELEOSTOMI.	III. HOLOCEPHALI.	IV. DIPNOI.
1. Archipterygium (elongate or abbreviate).	ICHTHYOTOMI.	CROSSOPTERYGII. (Palæoz. and Mesoz.)	[Unknown.]	SIRENOIDEI.
2. Pectorals di- or tribasal; pelvics abbreviate.	SELACHII.	CROSSOPTERYGII. (Cainozoic.)	CHIMÆROIDEI.	[Unknown.]
3. Basal cartilages small or rudimentary.	ACANTHODII.	ACTINOPTERYGII.	[Unknown.]	ARTHRODIRA.

In the Catalogue the Teleostomi are arranged after the Holocephali and Dipnoi, on account of the overwhelming number of their representatives in the Mesozoic and Cainozoic faunas, in which they attain their extreme specialization.

Fritsch[1]) venture to place it in that subclass without much hesitation. Others (*e. g.* Huxley[2] and Traquair[3]), however, prefer to retain the arrangement originally suggested by Agassiz; and the current opinion seems to be that it is an annectent type between the Elasmobranchs and the so-called Ganoids[4].

The Elasmobranch characters of the Acanthodians were well summarized by Huxley (*op. cit.*) no less than thirty years ago, and all the statements still remain valid. The structure of the exoskeleton, the nature of the fin-spines, the absence of cranial bones, the absence of membrane-bones connecting the pectoral arch with the cranium, the exposed and well-separated condition of the gill-clefts, and the course of the "lateral line" between the scales on the trunk—all still remain typically Elasmobranch characters. It may also be added that another point of resemblance between the Acanthodians and ordinary Elasmobranchs is observable in the tail. In the heterocercal tail of a Teleostomous fish, when the upper lobe of the caudal fin disappears, it is invariably replaced by a series of ridge-scales; in the Elasmobranchs, on the other hand, though the disappearance of the upper caudal fin-lobe is frequent, it is always absolute, and leaves no trace of the former presence of the appendage in a modification of the squamation. The latter is the case among the Acanthodians, of which none but completely heterocercal types are known.

The so-called "Ganoid characters" of the Acanthodians were also enumerated by Huxley when discussing this group; but, unlike the previous series of statements, they have proved for the most part untenable. As pointed out by Pander[5] and Traquair[6], the resemblances between *Cheirolepis* and Acanthodians are merely superficial. The ring of circumorbital plates, suggesting a comparison with *Palæoniscus*, has lately been discovered by Newberry[7] in a Palæozoic

[1] A. Fritsch, 'Fauna der Gaskohle,' vol. ii. (1889), p. 96.

[2] T. H. Huxley, Mem. Geol. Surv. dec. x. (1861), p. 38.

[3] R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. (1881), p. 18; also Geol. Mag. [3] vol. v. (1888), p. 511. A query is appended to the arrangement in Proc. Roy. Soc. Edinb. vol. xvii. (1890), p. 387.

[4] K. A. von Zittel, 'Handbuch der Palæontologie,' vol. iii. (1887), p. 165.

[5] C. H. Pander, 'Ueber die Saurodipterinen, Dendrodonten, Glyptolepiden, und Cheirolepiden des devonischen Systems' (1860), pp. 69–73, with plates.

[6] R. H. Traquair, Ann. Mag. Nat. Hist. [4] vol. xv. (1875), p. 240, pl. xvii.

[7] J. S. Newberry, Mon. U.S. Geol. Surv. no. xvi. (1889), p. 104 ("eye-capsules"), pl. xliv. fig. 3 (*Cladodus kepleri*).

fish which all will agree is a typical Elasmobranch. The "production of the pectoral arch into long backwardly directed processes in *Diplacanthus*," leading to a comparison with the Siluroids, is due merely to a pair of spinous fin-rays, which have no known analogues either among Elasmobranchs or Teleostomes. The "great spines articulated with the pectoral arch" cannot be regarded as of much significance. The so-called "oral tentacles" are endoskeletal structures, and probably represent the ceratohyal bones with their appended rays. Finally, the contention that the Acanthodii may be a degenerate branch of the "ganoids" that has followed and even descended beneath the Chondrostean Polyodontidæ, seems as destitute of philosophical basis as the contrary supposition that they form an Elasmobranch type on the verge of entering the Teleostomi.

According to all reliable observations, when a bony squamation degenerates, it is never accompanied by a simultaneous development of the insignificant surface-layer of cosmine and vascular dentine, but becomes replaced by a calcified tissue of thin lamellæ. It is thus contrary to widely-established principles to suppose that the order under consideration has developed from fishes with an osseous exoskeleton. On the other hand, the most typical of the early Teleostomi have archipterygial paired limbs, and hence cannot have been derived from the Acanthodii, which possess extremely specialized and abbreviated paired fins. The only alternative theory by which any connection whatever can be admitted between the two groups, seems to be the ordinary resource of a modern taxonomist in difficulties—the polyphyletic origin of the higher type.

Far from resorting to this solution of the problem, we prefer to interpret the anatomical characters of the Acanthodian fishes as proving that they occupy the same position in the Elasmobranch phylum that is held at the present day by the Actinopterygians in that of Teleostomi. Their abbreviate fins, degenerate dentition, and the partial development of membrane-calcifications [1], indicate their comparatively advanced status in whatever subclass they may be placed; and in the present condition of knowledge, it seems best to regard them as the culminating series of the Elasmobranchii at the time when this subclass was one of the dominant types.

The irregular manner in which membrane-calcifications (equivalent to membrane-bones, even if not osseous) are apparently deve-

[1] No bone-lacunæ have hitherto been detected in this tissue. The present writer has examined the mandibular splints of *Ischnacanthus* and *Acanthodopsis*.

loped among the Acanthodii is, indeed, a singular and interesting feature. So far as the observations recorded in the following pages have extended, such elements only occur in the head when the dentition is still preserved. In the lower jaw there is a bone probably corresponding to the splenial; and in the upper jaw there is an ensheathing element in connection with each half of the pterygo-quadrate arcade. In the pectoral arch, again, membrane-calcifications have only been noticed when there are great dermal spines to be supported. Two elements, occupying the position of clavicle and infraclavicle, are especially conspicuous in the formidably armed *Diplacanthus* (see p. 23); while in the comparatively feeble types of Acanthodidæ and Ischnacanthidæ, such calcifications are either insignificant or absent. Under any circumstances the development of membrane-elements in the Acanthodii cannot be regarded as more than a family character; and it is a striking illustration of the now generally received principle, that features which become of wide taxonomic importance in the higher groups are sporadic and of small significance on their first appearance in the lower groups.

Lastly, it may be remarked that, notwithstanding the extreme specialization of the paired limbs, the lower Acanthodians are the only vertebrates in which there are any structures in the adult, apart from the two pairs of fins, which may be plausibly interpreted as remnants of once-continuous lateral folds[1]. As observed by Prof. Cope[2], the earliest known members of the order (e. g. *Climatius*) exhibit between the pectoral and pelvic fins a close and regular series of paired spines, in every respect identical with those supporting the appendages that presumably correspond to the two pairs of fins in the higher genera. They may even have supported fin-membranes, though specimens sufficiently well preserved to determine the point have not yet been discovered. However, it is evident that dermal calcifications attained a greater development in the Acanthodii than in any of the more typical Elasmobranchs; and much additional information on the subject may be expected when the great fishes to which some of the undetermined Ichthyodorulites pertained become known.

[1] We do not overlook the theory of the rudimentary third pair of limbs in *Callorhynchus* (T. J. Parker, 'Nature,' vol. xxxiv. 1886, p. 635).

[2] E. D. Cope, Amer. Nat. vol. xxiv. (1890), p. 407.

HOLOCEPHALI.

Of the evolution of the Chimæroids—the only known order of this subclass—palæontology at present reveals very few particulars. In the Lower Devonian rocks there are dental plates essentially similar in character to those of the still-existing Chimæridæ; and in the earliest known Chimæroid skeleton—that of *Squaloraja* from the Lower Lias—the paired fins also differ in no particular from those of its surviving congeners. The Squaloraiidæ and Myriacanthidæ, however, exhibit some features in their dentition which may be regarded as comparatively primitive; and in other respects both these early families display a few characters resulting from specialization, such as have not been attained in the more persistent and later types.

As originally pointed out by Egerton[1], the dentition of the Myriacanthidæ (and we may add also that of the Squaloraiidæ) presents considerable superficial resemblance to that of certain Cochliodont Elasmobranchs; and it is thus easy to conceive how it may have been developed, in a similar manner, from a dental armature such as was possessed by the earliest members of the last-named subclass. In every respect the evolution has advanced further than in the Cochliodonts, all anterior prehensile teeth having disappeared; and the growth of the dental plates, instead of taking place exclusively at the inner border, seems to have gradually extended to the whole of the attached surface. The Chimæridæ exhibit an advance beyond the two families just considered, in the circumstance that all the dental plates are thickened, while the hinder upper pair are both closely apposed in the median line and much extended backwards.

The characters in which *Squaloraja* and *Myriacanthus* exhibit a higher degree of specialization than the later Chimæroids are the extreme development of the vertebral rings in the former and the presence of extensive dermal plates in the latter.

OSTRACODERMI.

At the conclusion of the sections on Elasmobranchii and Holocephali, the numerous undetermined fragments of dermal armour, chiefly consisting of vascular dentine, and hence probably referable to one or other of the subclasses just discussed, are provisionally arranged as Ichthyodorulites. A large number of these are still

[1] Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xxviii. (1872), p. 234.

problematical; and it has thus been deemed convenient to treat next in order the great extinct group of Chordate animals to which Prof. Cope[1] has applied the name of Ostracodermi. These pertain either to the Class Pisces or to some lower denomination yet to be determined.

Though placed in immediate association with the Urochorda and Agnatha by Cope, and lately supposed to be allies of the Arachnids by Patten[2], few facts can be advanced in favour of either of these theoretical interpretations of the group. The Arachnid theory is based upon a complete misapprehension of the most fundamental points in Ostracoderm skeletal anatomy[3]; while the comparison of the dorsal opening in the cranial shield of the Asterolepidæ with the mouth of an Ascidian, as originally made by Cope[4], is already admitted by that author himself[5] to prove untenable. That there were no hard parts round the mouth and in relation to paired appendages capable of being preserved under the ordinary conditions of fossilization seems to be satisfactorily demonstrated; but there is no justification for any further statement that jaws, pectoral and pelvic arches were absent. On the other hand, a symmetrical paired series of lateral indentations on the visceral aspect of certain Ostracoderm dorsal shields (e. g., *Cyathaspis*[6]) suggests the original presence of well-separated gill-pouches, between which it is reasonable to infer there were supporting elements of the nature of visceral arches. There is a distinctly movable flap or plate at the posterior opening of what appears to have been a common gill-cavity outside these pouches in some genera (e. g., *Cephalaspis* and *Pterichthys*). In every instance when the plate between the orbital apertures can be distinctly observed there is a small deep pit on its visceral aspect, sometimes projecting as a tubercle externally; and this occupies the precise position that would have been held by the pineal body of a vertebrate brain, had such been present. A pair of >-shaped impressions on the visceral aspect of the dorsal shield

[1] E. D. Cope, Amer. Nat. vol. xxiii. (1889), p. 852.

[2] W. Patten, Quart. Journ. Micro. Science, vol. xxxi. (1890), pp. 359–365, fig. 13.

[3] A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. vi. (1890), pp. 314–316.

[4] E. D. Cope, Amer. Nat. vol. xix. (1885), p. 290.

[5] E. D. Cope, *ibid.* vol. xxii. (1888), p. 915.

[6] See especially the figures by Kunth, Zeitschr. deutsch. geol. Ges. vol. xxiv. (1872), pl. i. fig. 1; A. von Alth, Abh. k. k. geol. Reichsanst. vol. vii. no. 1 (1874), pl. v. fig. 1; and Lankester, 'Cephalaspidæ' (1868), pl. ii. fig. 11.

occurring further backwards, and especially distinct in *Cyathaspis*[1], are exactly such as might result from contact with ridges upon the auditory capsules, due to a great development of the upper semicircular canals, as in Sharks. In short, all positive characters are rather in favour of an alliance with the class Pisces than otherwise; and although these organisms cannot be defined with scientific precision, it seems advisable at present to regard them as a primitive Piscine subclass of uncertain affinities.

The name Ostracodermi is preferred for this subclass, because Prof. Cope seems to be the only naturalist who has hitherto ventured to remove the Coccostean fishes far from the order that comprises the Asterolepidæ. So long ago as 1848, M'Coy[2] proposed to institute the "family Placodermi" for the Asterolepidæ and Coccosteidæ, allowing *Cephalaspis* to remain as the type of a distinct family; and all subsequent authors seem to have adopted this arrangement, with only slight changes in the rank allowed to the great divisions. Even so recently as 1888, Traquair[3] regarded the Asterolepidæ and Coccosteidæ as separated by characters merely of family value; and in the latest work of Newberry[4], the same classification, though not systematically formulated, is implied. It must, however, be remarked that both Newberry, Traquair, and other authors have on several occasions pointed out the close resemblance between the dentition of the Coccosteidæ and that of the Dipnoi; and it is by extending this suggestion to its logical issue, in the light of the latest researches, that the classification adopted in the following Catalogue has been attained. The Coccosteidæ and their allies possess ossified jaws and a dentition that are far from incipient or rudimentary. Some are believed to have had pectoral fin-spines (e. g., *Dinichthys* and *Brachydirus*)—a circumstance implying the presence of highly specialized paired fins; and even where pectorals have not been observed (e. g., *Coccosteus*), membrane-bones identical with those of an ordinary pectoral arch are certainly well developed. *Coccosteus*, moreover, is now proved to exhibit highly specialized pelvic fins. These characters suffice, at least in the present state of knowledge, to separate the *Coccosteus*-like fishes very widely from those now termed Ostracodermi; and it may be added that even detached fragmentary plates can in many

[1] See Kunth, von Alth, and Lankester's figures already quoted.
[2] F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 6.
[3] R. H. Traquair, Geol. Mag. [3] vol. v. (1888), pp. 508, 511.
[4] J. S. Newberry, 'Palæozoic Fishes N. America' (1889).

cases be readily distinguished. All the dermal armour of the Ostracoderms is characterized by an extraordinary development of vascular sinuses or channels in the middle layer, while that of *Coccosteus* and its allies consists of nearly homogeneous dense bone with only a slightly cancellated structure in its thicker portions.

The marked affinity between the Heterostraci and Osteostraci has already been demonstrated by Huxley [1] and Lankester [2]; and all the recent observations detailed in the following Catalogue tend to confirm the general results of that demonstration. It is, however, necessary to add a few remarks on the relationship now perceived between the Antiarcha (*i. e.*, the family Asterolepidæ) and the Osteostraci; more especially as these have not hitherto been enumerated, and Cope's statement on the subject is made with hesitation. The comparatively specialized genera *Auchenaspis*, *Didymaspis*, and *Trematapis* may first be compared with *Pterichthys* in the arrangement of the dermal armour. In each case the head exhibits only a dorsal shield, while the abdominal region is covered both dorsally and ventrally by an armature that meets in a close suture laterally. As clearly shown in *Trematapis*, and less distinctly observed in the other Osteostraci just mentioned, the ventral shield terminates abruptly in front, as in *Pterichthys*; and the only fundamental difference between the specialized Osteostracan and the ordinary Antiarchan type seems to be that the armature of the former consists of few plates, while these are subdivided in the latter. In the Antiarcha, again, the interorbital or pineal plate is always loose so far as known, while it is fixed in all Osteostraci except *Trematapis*; but even when fixed the outline can be readily distinguished in some examples of Cephalaspidæ, and there is a fine fragment of *Eukeraspis* displaying the contour of this element in the Ludlow Museum. In the absence of narial openings in the cranial shield, both types also agree; and the olfactory organ, if present, must thus have retained its embryonic situation on the ventral aspect immediately in front of the mouth. In short, so far as the shield can afford a clue to the essential soft parts, these were arranged upon one and the same plan in Heterostraci, Osteostraci, and Antiarcha.

Finally, the caudal region, as known in *Cephalaspis*, may be compared with that of *Pterichthys* in all essential particulars; and

[1] T. H. Huxley, Quart. Journ. Geol. Soc. vol. xiv. (1858), pp. 267–280, pls. xiv., xv.

[2] E. R. Lankester, 'The Cephalaspidæ' (Mon. Palæont. Soc. 1867–69).

although there are no paired appendages in the former genus, we are inclined to think that another noteworthy point of resemblance occurs in the appendicular skeleton, the rows of plates in the paddles of the Asterolepidæ being an extreme modification of the arrangement observed in the azygous fin-membranes of the Cephalaspidæ, and markedly different from the actinotrichian development by which the fin-rays of ordinary fishes arise. Even the support of the anterior border of the dorsal fin of *Pterichthys* is not a true spine, but merely a longitudinally bent (perhaps primitively double) scale.

DIPNOI.

Concerning the evolution of the Dipnoi, palæontology as yet affords no information. So long ago as the Devonian period, there were members of the subclass agreeing precisely with the existing *Ceratodus* in the development of the fins and the axial skeleton of the trunk. At that remote period, too, the chief part of the dentition had assumed the form of great plates upon the splenial bones and the palate; and the principal difference between such a type as *Phaneropleuron* and the existing genus just mentioned seems to consist in the comparative fewness of the cranial roof-bones in the latter and the absence of membrane-bones on the margin of the jaw. The typical Dipnoi of the Devonian period had, indeed, already become more specialized than any known in later times; *Dipterus* exhibiting differentiated dorsal fins and a heterocercal tail.

The latter fact is of all the more interest when the tendency of modern research in regard to the *Coccosteus*-like fishes is taken into consideration. According to existing diagnoses, these fishes must be assigned either to the Dipnoi or to the Teleostomi; and the extremely specialized character of their paired fins, so far as known, proves that, wherever they be placed, they occupy a comparatively high position. If they are Teleostomi, they pertain to the Actinopterygian order, and hence ought to exhibit a well-developed hyomandibular bone. At least, in every undoubted Actinopterygian Teleostome possessing ossifications equal in extent to those of *Coccosteus* and its allies, the hyomandibular bone is both large and considerably ossified. In the extinct group now under discussion, however, such a bone is not exhibited even by the most exquisitely preserved specimens. On the other hand, all appearances in the crania of *Dinichthys* and allied genera from the Waverly

Group of the United States are in favour of the supposition that they are truly autostylic. As originally pointed out by Newberry [1], the dentition of *Dinichthys* is most nearly paralleled by the existing Dipnoan *Protopterus*. The recently discovered triturating plates of *Mylostoma* would have been assigned to the Dipnoi or Chimæroidei, if they had not fitted certain associated mandibular bones identical in shape with those of the *Dinichthys*-type: on one page, indeed, Newberry terms the fish a "Placoderm" [2], while on another it is a "Dipterine Ganoid" [3]. The bones of the cranial shield, while apparently homologous throughout the group, cannot be described by the terms that are applicable to all Teleostomi, except perhaps the modern Acipenseroids; but these bones are symmetrically disposed with respect to the median longitudinal line, and are thus worthy of a nomenclature. In short, the evidence in favour of the autostylic character of the Coccostean fishes has now accumulated to such an extent, that we venture to regard them as an order of Dipnoi, bearing the same relation to the Sirenoidei that the Acanthodians seem to hold with respect to the primitive Elasmobranchs (Ichthyotomi), or the Actinopterygians with respect to the primitive Teleostomes (Crossopterygii). For this order the name ARTHRODIRA is suggested, in allusion to the ginglymoid articulation by which the cranial shield is hinged upon the anterior border of the armour of the abdominal region in the typical and best known genera.

TELEOSTOMI.

It is generally admitted that the Crossopterygian Teleostomi are closely related to the Dipnoi, and the Devonian representatives of this order tend in some degree to lessen the hiatus between the two great subclasses. Since, however, all the early Crossopterygii hitherto discovered conform to the normal Teleostome type in the arrangement of the bones of the cranial shield, it seems probable that the two groups had already diverged before the development of membrane-bones commenced.

The most interesting feature of the Crossopterygii consists in the mode of specialization of their fins; and this, as pointed out by Cope, affords a satisfactory basis for the definition of the suborders. In all the known Palæozoic and Mesozoic members of the order the

[1] J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 6.
[2] J. S. Newberry, 'Palæoz. Fishes N. America' (1889), p. 122.
[3] *Ibid.* p. 161.

paired fins are truly archipterygial, whether elongate or abbreviate; while in the existing Polypteridæ the pectoral fins have lost all trace of the original branched arrangement of the cartilages (precisely like the Sharks), and in *Polypterus* itself the pelvic fins are approximately in the same condition as those of one of the Actinopterygian Chondrostei. Among the early families, the characters of the median fins lead to the recognition of two or three divisions. It is probable that one type in which the median fin remains undivided and more or less in its primitive condition will eventually be met with, even if it be not already known. This group has received the name of HAPLISTIA, and we provisionally assign to it the problematical Tarrasiidæ. The second and third types, though now clearly definable, are not satisfactorily formulated in the somewhat fluctuating classifications of Cope; and the terms RHIPIDISTIA and ACTINISTIA are selected on the present occasion from those already proposed by that author, as being most expressive and accurate. For their diagnosis and description, reference may be made to the Catalogue itself; and it only seems necessary here to remark upon the extraordinary manner in which the specialized dorsal fins of the Rhipidistia resemble paired limbs (see especially fig. 50, p. 335). When subdivided, the dorsal fin invariably degenerates to two portions, and these are supported on a plan that does not differ much from that of an abbreviate archipterygium.

The great group of Actinopterygian Teleostomi is that concerning which palæontology affords most extensive information; but as only the typically Palæozoic families of Palæoniscidæ and Platysomatidæ are comprised in the present volume, it will be convenient to defer general observations on their relationships until the completion of Part III.

In conclusion, there is little to add concerning the details of the plan of the Catalogue to the statement already made in the Introduction to Part I. Family names derived from generic names terminating in *-aspis* and *-lepis* occur now for the first time; and, from the point of view of euphony, it has been deemed advisable to omit the reduplication of "*id*," which would be necessitated by a strict adherence to classical rule. There is already justification for this procedure in the universal adoption of the term Crossopterygii instead of the strictly accurate Crossotopterygii. More descriptive sections have been included than in the former volume, on account of the importance of the Palæozoic types to the modern Biologist,

and the want of any general work on the subject comprising the latest discoveries. The entirely novel points in most of these descriptions are few; but in every case the statements are based upon personal observation, unless the contrary be definitely remarked. Finally, an attempt is made to render the Catalogue more nearly complete in recording the collections where the various type specimens are preserved; but it is still impossible to trace many of the types originally in private collections, and a large proportion of these have doubtless been lost.

In this volume, as in the last, much is provisional, and can only be regarded as a tentative basis upon which to found more elaborate researches as additional materials and facilities for comparison accumulate. So far as practicable, however, all evidence bearing upon the subject has been taken into consideration; and in addition to consulting the principal British Collections, the writer has had the privilege of visiting those of Berlin, Breslau, Munich, Prague, Stockholm, St. Petersburg, Moscow, New York, Philadelphia, Ottawa, Montreal, and Cambridge (Mass.), all of which comprise specimens of essential importance. To the Professors in the various Universities and the Curators of the Museums, thanks are respectfully tendered for the facilities and kind assistance they have invariably afforded; and both to Mr. William Davies, F.G.S., and Dr. R. H. Traquair, F.R.S., as also to Mr. James W. Davis, F.G.S., and Mr. John Ward, F.G.S., the writer is under the deepest obligations for continued help and advice.

ARTHUR SMITH WOODWARD.

Geological Department,
January 20th, 1891.

List of Collections.

In addition to the Collections enumerated in Part I. (p. xxix), the following are also referred to in the present volume:—

Bryson Collection.—A series of fossil fishes and plants, chiefly from the Scottish Carboniferous, collected by the late Mr. James Bryson, of Edinburgh, and obtained by purchase, 1868.

Goldenberg Collection.—A small collection of fossils from the Lower Permian of Rhenish Prussia, made by Dr. F. Goldenberg (author of 'Fauna Saræpontana Fossilis,' 1873–77), purchased 1889.

Lightbody Bequest.—A portion of the collection of the late Mr. Robert Lightbody, F.G.S., of Ludlow, comprising fossil fishes from

the Upper Silurian and Old Red Sandstone of Herefordshire, bequeathed to the Trustees, 1874.

Peach Collection.—A series of fossil fishes from the Lower Old Red Sandstone, chiefly of Caithness, collected by the late Mr. Charles W. Peach, A.L.S., obtained by purchase, 1870.

Whincopp Collection.—Fossils from the Pliocene Crags of Suffolk and Norfolk, collected by the late Mr. W. Whincopp, of Woodbridge, purchased through Mr. E. Charlesworth.

It may be added that a few of the type specimens of Ichthyodorulites from the Carboniferous Limestone, formerly in the Collection of the Earl of Enniskillen, were lost in transit immediately before the acquisition of this Collection by the Museum. These specimens are noted in the Catalogue as "*olim* Enniskillen Collection."

Supplement.

On account of the rapid progress of researches in Fossil Ichthyology at the present time, it seems advisable to defer the issue of any Supplement to this Catalogue until its completion. In regard to Part I., we would thus only add that a recent discovery (Proc. Zool. Soc. 1889, p. 450) suggests that the so-called *Squatina crassidens* is the trunk of *Sclerorhynchus atavus*; while an important Permian genus and species, *Dichelodus acutus* (C. Giebel, Zeitschr. gesammte Naturw. vol. ix. 1857, p. 121, pl. iv.), is unfortunately overlooked, both in this Catalogue and apparently in all the synoptical accounts of the Cochliodontidæ hitherto published.

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CATALOGUE

OF

FOSSIL FISHES.

PART II.

Subclass I. ELASMOBRANCHII (*continued*).

Order III. ACANTHODII.

Notochord persistent; endoskeletal cartilage superficially calcified, often granulated. Cranial roof covered with irregular small dermal elements, and orbit frequently surrounded by circumorbital plates; teeth, when present, firmly fixed to membrane-bones upon the pterygoquadrate and mandibular cartilages. Gill-arches each with a close series of prominent dermal appendages, probably supports for a cutaneous flap. Endoskeletal cartilages of all the fins much abbreviated, and the dermal expansion almost or completely destitute of rays; each of the paired fins and most of the median fins provided with an anterior spine; no claspers in the male. Tail heterocercal. Dermal armature of trunk consisting of small, closely arranged, quadrate granules, which also extend over the greater portion of the fins; lateral line passing between two series of the granules.

Synopsis of Families.

A. One dorsal fin.
   Clavicular bones absent ..... ACANTHODIDÆ (p. 2).
B. Two dorsal fins.
   Clavicular bones absent ..... ISCHNACANTHIDÆ (p. 20).
   Clavicular bones present ..... DIPLACANTHIDÆ (p. 22).

Family ACANTHODIDÆ.

A single dorsal fin present, both this and the anal with an anterior spine. Clavicular bones absent.

Synopsis of Genera.

A. Teeth minute or absent.
  Dorsal fin not in advance of anal..... *Acanthodes* (p. 2).
  Dorsal fin in advance of anal ..... *Cheiracanthus* (p. 16).
B. Teeth large.
  [Arrangement of fins unknown.]..... *Acanthodopsis* (p. 15).

Genus **ACANTHODES,** Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1833, p. 19.]

Syn. *Acanthoessus,* L. Agassiz, Neues Jahrb. 1832, p. 149.
Holacanthodes, E. Beyrich, Monatsb. Berl. Akad. 1848, p. 24.
Mesacanthus, R. H. Traquair, Geol. Mag. [3] vol. v. 1888, p. 511.

Body elongate, tapering, and laterally compressed. Teeth minute or absent; orbit with ring of four circumorbital plates. Pectoral fins very large; pelvic pair smaller. Dorsal fin remote, never arising in advance of a point opposite the anal fin-spine.

Fig. 1.

Restoration of *Acanthodes wardi,* Egert.—Coal-Measures, England and Scotland.

This, the type genus of the family and order, has been more thoroughly investigated than any of the allied genera[1]. It thus seems advisable to summarize the known facts in the anatomy of the fish, and compare some of its more striking features with those presented by certain members of the Diplacanth family.

In the head, the suspensorium is oblique and the gape of the mouth correspondingly wide. The orbit is placed far forwards, and the upper jaw evidently projects somewhat in advance of the lower. The cartilage of the cranium and jaws is partially strengthened by

[1] See especially the memoirs of Roemer and Kner, quoted in the synonymy of *A. bronni.*

minute granular calcifications. There is no definite evidence of membrane-bones bordering the mouth; but in genera which possess teeth (*e.g. Acanthodopsis* and *Ischnacanthus*) the oral margin both of the upper and lower jaws is ensheathed in a well-developed membrane-bone. In the small species from the Old Red Sandstone the roof of the skull is distinctly covered with an irregular mosaic of small dermal scales; and in all the species a circumorbital ring of four dermal plates is conspicuous. Between the rami of the lower jaw, there occurs a pair of slender cartilages, not expanded at the extremities, but firmly calcified; and these are accompanied by a sparse series of delicate rays in such a manner as to suggest that they represent the ceratohyals[1]. The branchial arches, of which there are five, are also calcified; and on the hinder or convex margin of each is arranged a close series of lanceolate appendages, having the free extremity broader than the attached end, and not improbably destined for the support of dermal flaps, resembling those upon the gill-arches of the recent "frilled shark," *Chlamydoselache*.

The cast of a pair of large oval lobes has been observed in the head of a Siberian species[2], these not improbably indicating the form and proportions of part of the cerebral cavity.

In the axial skeleton of the trunk the notochord is persistent, and the arches are so rarely observable that they must have been very slightly calcified. There are no traces of ribs, but a series of slender neural arches is feebly indicated in a specimen from the Calciferous Sandstones of Eskdale (no. P. 5979, p. 10); and stout hæmal arches are sometimes preserved in the region of the caudal fin in examples of the type species from the Permian nodules of Rhenish Prussia.

Each of the fins, except the caudal, is provided with an anterior spine, which resembles that met with in the dorsal fins of many well-known Selachians, and is to be similarly regarded as an enormous dermal ray. The fin-membrane is always stiffened by quadrate dermal granules of the same nature as those covering the trunk, and these are often arranged in regular lines simulating rays; but the pectoral and caudal are the only fins in which any traces of the endoskeletal elements have hitherto been observed.

At the base of each pectoral fin-spine (fig. 2) there abuts against its posterior or concave border the broader end of a supporting cartilage (*b*), which is elongated in a direction at right angles to the spine (*s*), is constricted shortly above this articulation, and ends

[1] "Oral tentacles" of Huxley, and "styliform bones forming the rami of the lower jaw" of Egerton.

[2] J. V. Rohon, Mém. Acad. Imp. Sci. St. Pétersbourg, [7] vol. xxxvi. no. 13 (1889), p. 4, pl. i. figs. 8, 9.

proximally in a smaller, abruptly truncated expansion. This element has a thick, smooth, calcified surface, and its long axis

Fig. 2.

Skeleton of pectoral fin of *Acanthodes bronni*, Ag.
b, basal cartilage; *r*, fibrous rays; *s*, anterior spine.

seems to have been originally more or less vertical, while there is no evidence of a connection with its fellow of the opposite side. By Huxley, Kner, Egerton, and others, this has been regarded as a representative of the pectoral arch; and the interpretation may appear at first sight justified by the relatively large size of the cartilage in some Diplacanth genera. To the present writer, however, the element in question seems to pertain to the basipterygium; for it exhibits the same relative size and position as the basal cartilage in the spinous dorsal fins of several sharks; and in a well-preserved example of another Acanthodian, *Parexus falcatus* (No. P. 130, p. 35), a much larger, expanded, triangular element, more delicate, apparently meets its fellow in the middle line, and occupies the position with respect to the spine that a pectoral arch might be expected to hold. No other cartilage is recognizable, but at a short distance below the supposed basipterygium there occurs a close series of short, fine dermal fin-rays (*r*), sometimes appearing as the fringe of a short obtuse lobe; and it may be that these mark the precise limit of the endoskeletal part of the appendage.

As often shown in the type species [1], the anterior part of the lower lobe of the caudal fin is supported by a series of long, stout, basal cartilages (? hæmal spines), each apposed to a short hæmal arch, but distinctly separated from the latter. The Acanthodian caudal fin thus presents a resemblance to the corresponding fin of certain Selachians, *e. g. Mustelus antarcticus* [2].

[1] Kner, Sitzungsb. k. k. Akad. Wiss. Wien, math.-naturw. Cl. vol. lvii. pt. i. pl. v. fig. 2, pl. vii. fig. 1.

[2] Mivart, Trans. Zool. Soc. vol. x. (1879) p. 441, pl. lxxiv. fig. 6.

The squamation appears to be of equal fineness over the whole of the trunk, there being no fulcral scales even on the upper caudal lobe; while the only diminution in the size of the quadrate granules occurs in this region and towards the distal margins of the fins. The scales are either rectangular or slightly rhomboidal, with a flattened or faintly excavated external surface, usually smooth; and their attached surface exhibits a gentle convexity. A single lateral line occurs high on each flank, marked not by any tubular or other excavation of the scales, but by the ridge-like displacement of two series, between which the organ originally extended. The supposed evidence of additional sensory canals appears to the present writer to be due to a misinterpretation of the displaced dorsal and ventral ridges, which exhibit no median series of scales.

The evolution of the paired fins in the successive species of *Acanthodes*, as defined below, is of some interest. In the Upper Devonian representatives of the genus the pelvic fins are not much inferior in size to the pectorals, and are placed nearly midway between the latter and the anal. In the Lower Carboniferous *A. nitidus* the pelvic fins are similarly placed, but reduced in size. In the Upper Carboniferous *A. wardi* the same fins are not only further reduced, but occupy a more forward position, while the pectorals are much enlarged. In the Lower Permian species the pelvic fins become insignificant and the pectoral fins enormous, while the two pairs are even more closely approximated than in the earlier forms.

Acanthodes bronni, Agassiz.

1832. *Acanthoessus bronnii*, L. Agassiz, Neues Jahrb. p. 149.
1833–35. *Acanthodes bronnii*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 20, 124, pl. i.
1848. *Holacanthodes gracilis*, E. Beyrich, Monatsb. Berl. Akad. p. 24.
1857. *Acanthodes gracilis*, F. Roemer, Zeitschr. deutsch. geol. Ges. vol. ix. p. 65, pl. iii.
1857. *Acanthodes bronnii*, F. H. Troschel, Verhandl. naturh. Ver. preuss. Rheinl. u. Westph. vol. xiv. p. 2, pls. i., ii. figs. 1–13.
1861. *Acanthodes gracilis*, H. B. Geinitz, Dyas, p. 21.
1864. *Acanthodes bronnii*, E. Weiss, Zeitschr. deutsch. geol. Ges. vol. xvi. p. 291.
1868. *Acanthodes bronnii* and *A. gracilis*, R. Kner, Sitzungsb. k. k. Akad. Wiss. Wien, math.-naturw. Cl. vol. lvii. pt. i. p. 303, pls. v.–viii.

Type. Imperfect fish; *olim* H. G. Brown Collection.

The type species, attaining a maximum length of about 0·3. Body much elongated and slender, the maximum depth being contained about six or seven times in the total length. Pectoral fin-

spines broad and robust, much laterally compressed, very slightly arched, with one very prominent, oblique, longitudinal ridge and groove and several minor grooves; pelvic fin-spines relatively small, scarcely attaining one quarter the size of the pectorals. Pelvic fins placed far forwards, the length of the space between this pair and the pectorals equalling about one half that of the space between it and the anal. Anal fin-spine half as large as the pectoral; dorsal still slightly smaller, situated a short distance behind the anal. Scales smooth or with a median pit.

According to the latest memoir on the subject—that by Kner—*A. bronni* is distinguished from the so-called *A. gracilis* by its less slender proportions, its relatively smaller scales, and the more posterior situation of the pelvic fins. The two forms, however, are determined as occurring together both in East and West Germany; and all the examples figured by Kner from Saarbrück (Rhenish Prussia) are named *A. gracilis*.

An examination of the series of specimens mentioned below, suggests to the present writer that the comparatively robust appearance of the type specimens of *A. bronni* and other fossils in the Saarbrück nodules assigned to this species is due entirely to imperfect preservation. The fishes have been buried in a coiled-up state, while the skin with its scales has been displaced by crushing; and, when a sharp outline is distinguishable, the body appears quite as slender as that of the well-preserved typical examples of *A. gracilis* occurring in the fine shale of Klein Neundorf. The size of the scales is also inconstant, and we can therefore, as yet, determine only one species in the German Rothliegendes.

Kner describes, as characteristic of this species, the presence of a small spine bounding the posterior margin of the pectoral fin. The statement, however, seems to have been based upon a mistake in observation; for the specimens in the Collection exhibit no such spine, and in one case cited (Kner, pl. v. fig. 1) it may well be a fragment of an ordinary pectoral, while in the other case (Kner, pl. vi. fig. 1) it is probably the pelvic fin-spine somewhat displaced.

Form. & Loc. Lower Permian (Rothliegendes): Germany.

22658 a. A small specimen completely coiled upon itself, in a nodule; Saarbrück, Rhenish Prussia. The circumorbital plates and the gill-arches are shown in the region of the head. *Purchased*, 1848.

40048–50. One nodule with obscure remains of a fish of moderate size; another with remains of a large head and anterior portion of the abdominal region; and a third nodule con-

taining a small coiled fish, tolerably well preserved; Lebach, Rhenish Prussia. *Purchased*, 1866.

P. 1324, P. 4477. Nodule with an imperfect fish resembling that figured by Agassiz, *tom. cit.* pl. i. fig. 1; Lebach.
Egerton and Enniskillen Colls.

P. 1324 a, P. 3249. Specimen in a large nodule, not coiled, and only slightly crushed; Lebach. In the region of the head are remains of the circumorbital plates and branchial arches; and the pectoral, pelvic, and dorsal fin-spines are more or less imperfectly preserved.
Egerton and Enniskillen Colls.

P. 4477 a. Half of nodule containing the head and the greater portion of the coiled-up trunk; Lebach. Some of the circumorbital plates and remains of the granular dermal covering of the head are preserved; fragments of branchial arches occur below and behind the head; and all the fin-spines are shown, at least in part. *Enniskillen Coll.*

P. 6192. Five small specimens, one being in counterpart; Lebach.
Goldenberg Coll.

P. 6192 a. Remains of head and branchial arches; Lebach.
Goldenberg Coll.

33060, 33063. Five imperfect fishes, variously broken and distorted, preserved in shale, and displaying all the principal characters of the species; Klein Neundorf, near Löwenberg, Silesia. *Purchased*, 1858.

P. 1325. Four specimens in a similar state of preservation, but mostly finer; Klein Neundorf. *Egerton Coll.*

P. 3248. Small specimen, wanting extremity of tail; Klein Neundorf. The sketch of the pectoral fin given in fig. 2 is chiefly based upon this specimen. *Enniskillen Coll.*

38159. Caudal region of a very large fish, doubtfully of this species; Klein Neundorf.
Presented by Sir Roderick I. Murchison, K.C.B., 1864.

Acanthodes rouvillei, Sauvage.

1883. *Acanthodes rouvillei*, H. E. Sauvage, Bull. Soc. Géol. France, [3] vol. xi. p. 475, pl. x. fig. 1.

Type. Nearly complete fish.

A small species closely allied to *A. bronni*. Body much elongated

and slender, the head occupying about one sixth of the total length. Pectoral fin-spines relatively large, arched, and longitudinally striated; pelvic fin-spines very small, about one fifth as large as the pectorals, separated from the latter by a space much less than one half of the distance between them and the anal. Dorsal and anal fin-spines almost directly opposed, of nearly equal size, and more than half as large as the pectoral spine. [Scales unknown.]

The remarkable form of the head, as described by Sauvage, is doubtless due to imperfect preservation; and the supposed lower jaw has much the appearance of the styliform cartilage termed ceratohyal by the present writer.

Form. & Loc. Permian: Lodève, France.

Not represented in the Collection.

Acanthodes wardi, Egerton.

1866. *Acanthodes wardi,* Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xxii. p. 468, pl. xxiii.

1871. *Acanthodes wardii,* J. Thomson, Trans. Geol. Soc. Glasgow, vol. iv. p. 57, pl. iv.

1875. *Acanthodes wardi,* J. Ward, [Proc.] N. Staffs. Nat. Field-Club, p. 241.

1876. *Acanthodes wardi,* J. W. Davis, Quart. Journ. Geol. Soc. vol. xxxii. p. 335.

1890. *Acanthodes wardi,* J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 157, pl. v. fig. 2.

1890. *Acanthodes wardi,* R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 388.

Type. Imperfect fish; collection of John Ward, Esq., Longton.

A species closely resembling *A. bronni* in form and proportions. Pectoral fin-spines broad and robust, much laterally compressed, with a single groove and faint ridge nearly parallel to the anterior border and disappearing distally; other spines similar. Pelvic fin-spines relatively small, about one quarter the size of the pectorals; pelvic fins extremely elongated, arising at a point about three quarters as far from the pectoral fins as from the anal. Anal fin-spine half as large as the pectoral; dorsal still slightly smaller, placed a short distance behind the anal. Scales smooth, sometimes faintly hollowed mesially.

Form. & Loc. Coal-Measures: Staffordshire and Scottish Coal-fields.

36891. Remains of small fish, displaying proportions of pectoral and pelvic fin-spines; Deep-mine Ironstone, Longton, N. Staffordshire. *Purchased,* 1862.

P. 236. Fragment, showing circumorbital plates; Longton. *Weaver Jones Coll.*

P. 1326. Caudal region of a large fish, and the greater portion of two small fishes; Longton. *Egerton Coll.*

P. 1327. Portion of head and branchial arches, being the counterpart of the specimen figured by Egerton, *loc. cit.* fig. 2; Longton. Appearances in this fossil suggest that the gill-clefts were well separated by narrow bands of scale-covered skin. *Egerton Coll.*

P. 3250. Imperfect specimen of moderate size, and the caudal region of a small individual; Longton. *Enniskillen Coll.*

P. 5178. Well-preserved caudal region; Longton. *Purchased*, 1885.

An Acanthodian spine from the Coal-Measures of Buxière-les-Mines, Allier, France, closely resembling the pectoral of *Acanthodes wardi*, is named *Onchus simplex*, H. E. Sauvage, Bull. Soc. Géol. France, [3] vol. vi. (1878) p. 625, pl. xi. fig. 4. Similar spines, of small size, also occur in the Coal-Measures of Nova Scotia (Geol. Survey Museum, Ottawa, and Redpath Museum, Montreal).

Acanthodes nitidus, sp. nov.

Type. Imperfectly preserved fish; British Museum.

Body much elongated and slender, the maximum depth being contained about six times in the total length. Pectoral fin-spines broad, much laterally compressed, with a single groove and faint ridge nearly parallel to the anterior border and disappearing distally; other spines similarly grooved but somewhat more tumid in the proximal half. Pelvic fin-spines relatively small, about one third as large as the pectorals, situated halfway between the latter and the anal. Anal fin-spine at least half as large as the pectoral, larger than the dorsal, which is placed immediately behind. Scales smooth, the surface faintly excavated or flat.

So far as known, this species is readily distinguished from the closely allied *A. wardi* by the relatively larger size and somewhat more remote situation of the pelvic fins.

Form. & Loc. Calciferous Sandstones: Dumfriesshire.

P. 4057. The type specimen, being an imperfectly preserved fish, 0·22 in length, showing large portions of all the fin-spines in position, and displaying the characters noted in the diagnosis; Eskdale. *Purchased*, 1883.

P. 4058. Imperfect pectoral fin-spine and scattered scales; Eskdale. *Purchased*, 1883.

P. 5979. Greater portion of a smaller fish, preserved in counterpart, with indications of slender calcified neural arches; Eskdale. *Purchased*, 1889.

A fragment of squamation from the Calciferous Sandstones of Wardie, near Edinburgh, is named *Acanthodes sulcatus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. (1835) p. 125, pl. i *c*. figs. 1, 2. The specimen is preserved in the University Museum, Oxford, and must be regarded as specifically indeterminable. Under the same name, however, more satisfactory Acanthodian fossils have been briefly noticed by R. H. Traquair (Proc. Roy. Soc. Edinb. 1890, p. 392) from the Calciferous Sandstones of several localities in Fife and the Lothians, these being regarded as distinguishable from *A. wardi* only by "a somewhat greater straightness and slenderness of the 'styliform' bone."

Acanthodes pygmæus, Fritsch.

1875. *Acanthodes pygmæus*, A. Fritsch, Sitzungsb. k. böhm. Ges. Wiss. p. 74.

Type. Nearly complete fish; Royal Bohemian Museum, Prague.

A small species, about 0·08 in length, not yet defined, but to be described in a forthcoming part of Fritsch's 'Fauna der Gaskohle.' The scales are relatively large and smooth, and the median fin-spines long and slender.

Form. & Loc. Lower Permian: Bohemia.

P. 4157. Imperfect caudal region, showing dorsal and anal fin-spines, labelled by Prof. Dr. F. Roemer; Nyřan, near Pilsen. *Enniskillen Coll.*

Acanthodes concinnus, Whiteaves.

1887. *Acanthodes concinnus*, J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. iv. sect. iv. p. 107, pl. x. fig. 1.

1889. *Acanthodes concinnus*, J. F. Whiteaves, *ibid.* vol. vi. sect. iv. pl. v. fig. 2.

1890. *Acanthodes concinnus*, R. H. Traquair, Geol. Mag. [3] vol. vii. p. 16.

Type. Imperfect fish; Geological Survey of Canada, Ottawa.

A small species, attaining a maximum length of about 0·15; head occupying approximately one sixth of the total length. Fin-spines short and slender in proportion to the size of the fish, each

ornamented with about four longitudinal grooves. Pectoral spines stouter and longer than the others; pelvic spines small; anal spine slightly in advance of the dorsal. Scales minute, with faint diagonal striations.

Form. & Loc. Upper Devonian: Scaumenac Bay, P. Q., Canada. Not represented in the Collection.

The following small Devonian species have recently been assigned by R. H. Traquair to a distinct genus, *Mesacanthus*, characterized by the presence of a minute pair of free spines on the ventral surface between the pectoral and pelvic fins. The proportions of the paired fins are certainly somewhat different from those of the typical *Acanthodes*, and decided points of generic distinctness may eventually be discovered. At present, however, we propose to retain the long-accepted nomenclature; more especially as the minute additional pair of spines is not observable in any of the specimens mentioned below, except a few examples of *A. mitchelli*.

Acanthodes pusillus, Agassiz.

[Plate I. figs. 5, 6.]

1844. *Acanthodes pusillus*, L. Agassiz, Poiss. Foss. V. G. R. p. 36, pl. xxviii. figs. 8–10.

1888. *Mesacanthus pusillus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 512.

Type. Imperfect fish; Forres Museum.

A very small species, the largest specimen in the Collection (Pl. I. fig. 5) measuring not more than 0·06 in extreme length. Body elongated and slender, the maximum depth being contained about six or seven times in the total length; caudal lobe extremely elongated. Pelvic fins large, midway between the pectorals and the anal; pelvic spines not less than half the size of the pectorals, and two thirds as long as the anal spine. Dorsal fin arising behind the origin of the anal, slightly larger than the latter.

In the original description of *A. pusillus*, Agassiz mentions the presence of a series of small spines upon the lower border of the caudal region. The character, however, is not alluded to by Egerton when comparing this species with *A. peachi*, and it is not exhibited by any of the specimens enumerated below.

Form. & Loc. Lower Old Red Sandstone: Banffshire, Scotland.

35784–5. Two specimens, exhibiting the elongated upper caudal lobe; Tynet Burn. *Purchased*, 1860.

35786. A comparatively large specimen, shown, of the natural size, in Pl. I. fig. 5; Tynet Burn. The fish is distorted, and the outlines are somewhat obscured by the displacement of the scales; but several details are exhibited. In the head, the cartilages of the upper and lower jaws are indicated, and the ring of circumorbital dermal plates is preserved. Only a portion of one pectoral spine is observable; but the pelvic fin of the left side, with its spine, is complete, and exhibits a very long base-line. The large anal spine also occurs in position in front of a much elongated fin; and there is a fragment of the dorsal spine in its ordinary position. The upper caudal lobe is somewhat broken towards the extremity, but otherwise well preserved, as is also the greater portion of the caudal fin.
Purchased, 1860.

43019. A small coiled-up specimen, preserved in counterpart; Tynet Burn. *Purchased*, 1871.

P. 1329. Four small specimens, two being associated in one nodule. The largest of the latter is shown, of the natural size, in Pl. I. fig. 6; Tynet Burn. *Egerton Coll.*

Acanthodes peachi, Egerton.

1861. *Acanthodes peachi*, Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 57, pl. vi. figs. 1, 2.
1861. *Acanthodes coriaceus*, Sir P. Egerton, *ibid.* p. 59, pl. vi. figs. 3–5. [Museum of Practical Geology.]
1888. *Mesacanthus peachii*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 512.

Type. Nearly complete fish; Museum of Practical Geology, London.

A very small species, attaining a maximum length of about 0·06. Body more robust than in *A. pusillus*, the greatest depth being contained about five or six times in the total length. Pelvic fins large, midway between the pectorals and the anal; pelvic spines smaller than the pectorals, but almost or quite as long as the anal spine. Dorsal fin arising slightly behind the anal, and much larger than the latter.

Form. & Loc. Lower Old Red Sandstone: Caithness, Scotland.

33148. Imperfect specimen, showing the dorsal, anal, and pelvic spines, with portions of the pectorals and pectoral basipterygium; Thurso. *Purchased.*

49668–9. One very stout specimen and an imperfectly preserved caudal region, with impression of the head and abdominal region; Thurso. *Purchased*, 1879.

43967. Crushed fish, showing all the fin-spines; Thurso. *Purchased*, 1872.

38583. Slab with remains of several individuals. *Purchased*, 1864.

Acanthodes mitchelli, Egerton.

[Plate I. fig. 7.]

1860. *Acanthodes antiquus*, Sir P. Egerton, Rep. Brit. Assoc. 1859, Trans. Sect. p. 116 (name only).

1861. *Acanthodes mitchelli*, Sir P. Egerton, Rep. Brit. Assoc. 1860, Trans. Sect. p. 77; and Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 61, pl. vii.

1864. *Acanthodes mitchelli*, J. Powrie, Quart. Journ. Geol. Soc. vol. xx. p. 419.

1870. *Acanthodes mitchelli*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 288, pl. x. fig. 1.

1888. *Mesacanthus mitchelli*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 512.

Type. Complete fish; British Museum.

A very small species, attaining a maximum length of 0·065. Body elongated and slender, the greatest depth being contained about six times in the total length; cranial roof very coarsely rugose or consisting of large, irregular, tesseræ-like membrane bones. Pelvic fins large, situated somewhat nearer to the anal than to the pectorals; a pair of minute spines in advance of the pelvic pair. Pelvic spines about half as large as the pectorals, and two thirds as long as the anal. Dorsal fin arising behind the anal, larger than the latter.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

P. 560, P. 1330. Type specimen and a smaller more imperfect fish; Farnell, Forfarshire. The minute intermediate ventral spines are shown in Egerton's outline sketch, but not in the detailed enlarged figure, and apparently not in the original specimen. The second fossil exhibits these spines. *Egerton Coll.*

35909. Two contorted fishes; Farnell. *Presented by James Powrie, Esq.*, 1861.

38594. Almost complete fish, lateral aspect, shown, of the natural size, in Pl. I. fig. 7. *Presented by James Powrie, Esq.*, 1864.

38514–15. Crushed specimen, and another fish, lateral aspect; Turin Hill, Forfar. *Purchased*, 1864.

41362. Very small fish; Turin Hill. *Purchased*, 1869.

46307. Four specimens; Turin Hill. *Purchased*, 1875.

P. 126, P. 140. Contorted and crushed small individual, in counterpart, and an imperfect large fish; Turin Hill. *Purchased*, 1880.

P. 1331. Two specimens; Turin Hill. *Egerton Coll.*

P. 5081. Well-preserved specimen; Turin Hill. *Presented by J. E. Lee, Esq.*, 1885.

Acanthodes affinis, Whiteaves.

1887. *Acanthodes mitchelli* (?) or *Acanthodes affinis*, J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. iv. sect. iv. p. 107.

1889. *Acanthodes affinis*, J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 91, pl. v. fig. 1.

1890. *Mesacanthus affinis*, R. H. Traquair, Geol. Mag. [3] vol. vii. p. 16.

Type. Nearly complete fish; Geological Survey of Canada, Ottawa.

A very small species, about 0·04 in length. Body elongated and slender, the greatest depth being contained about five times in the total length. Pelvic fins large, situated somewhat nearer to the anal than to the pectorals; pelvic spines more than half as large as the pectorals, and about equal in size to the anal. Dorsal spine slightly behind the anal, scarcely larger than the latter.

Form. & Loc. Upper Devonian: Scaumenac Bay, P. Q., Canada.

P. 5975. Typical specimen, 0·03 in length. *Purchased*, 1889.

Two small Acanthodian fishes of the same type as the preceding are also known from supposed Devonian strata in Siberia, but there are no examples in the Collection. They are described as follows:—

Acanthodes lopatini, J. V. Rohon, Mém. Acad. Imp. Sci. St. Pétersbourg, [7] vol. xxxvi. no. 13 (1889), p. 3, pl. i. figs. 1–3, 6–9, 11, 12, 15–17.—Devonian (?); Isyndschul, near River Seresch, Govt. of Tomsk, Siberia. [Imperfect fishes; Imperial Academy of Sciences, St. Petersburg.]

Acanthodes parvulus, J. V. Rohon, *ibid.* p. 7, pl. i. fig. 5.—Ibid. [Imperfect fish, displaying caudal region; Imperial Academy of Sciences, St. Petersburg.]

A mass of scales, of indeterminable genus, from the Genesee Shale (Upper Devonian), Glenville, New York, is named *Acanthodes? pristis*, J. M. Clarke, Bull. U.S. Geol. Surv. no. 16 (1885), p. 42.

Genus **ACANTHODOPSIS**, Hancock & Atthey.

[Ann. Mag. Nat. Hist. [4] vol. i. 1868, p. 364.]

[Form of trunk and arrangement of fins unknown.] Dentition powerful, consisting of few large, laterally compressed, triangular teeth. Pectoral fin-spines relatively large.

This genus was originally founded upon some portions of jaws from the Coal-Measures of Northumberland, met with in association with pectoral fin-spines and shagreen, indistinguishable from the corresponding parts of *Acanthodes wardi*. The fish just mentioned was thus regarded as the type species of the genus, while a supposed second form, of larger size, received the name of *Acanthodopsis egertoni*.

Acanthodopsis wardi, Hancock & Atthey.

1868. *Acanthodopsis wardi*, Hancock & Atthey, Ann. Mag. Nat. Hist. [4] vol. i. p. 364, pl. xv. fig. 6 (reprinted in Nat. Hist. Trans. Northumb. & Durham, vol. iii. 1870, p. 103, pl. ii. fig. 6).

1868–70. *Acanthodopsis egertoni*, Hancock & Atthey, *ibid.* p. 367, and *ibid.* p. 107. [Jaw; Newcastle-upon-Tyne Museum.]

1880. *Acanthodopsis*, R. H. Traquair, Proc. Roy. Phys. Soc. Edinb. vol. v. p. 117.

1890. *Acanthodopsis wardi*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xxvii. p. 388.

Type. Jaws, &c.; Newcastle-upon-Tyne Museum.

The type species, having jaws attaining a length of about 0·5. Teeth at least as broad as deep, marked with fine vertical wrinkles, and confluent at the base; about six or eight in number on each side above and below, largest in the middle of the ramus, and without intermediate denticles. Pectoral spines long and laterally compressed, smooth, with an antero-lateral longitudinal groove. Dermal granules smooth.

Form. & Loc. Coal-Measures: Northumberland and Midlothian.

41202. Portion of jaw with two teeth; Low Main Seam, Newsham, near Newcastle. *Presented by T. P. Barkas, Esq.*, 1868.

P. 786–7. Three fragments of jaws, one also showing the proximal end of a ceratohyal; Newsham. *Egerton Coll.*

P. 3264. Two imperfect mandibular rami with ceratohyals, a jaw-fragment, and a detached ceratohyal; Newsham. *Enniskillen Coll.*

The following pectoral fin-spines may pertain either to *Acanthodopsis* or to a large form of *Acanthodes*:—

P. 1328. Imperfect spine, slightly arched, with a single longitudinal furrow near the anterior margin, preserved for a length of 0·11; also two associated portions of similar spines; Coal-Measures, Lowmoor, Yorkshire. *Egerton Coll.*

P. 3252. Two imperfect specimens, one larger, one smaller; Lowmoor. *Enniskillen Coll.*

P. 2285. Fragment of large spine; Coal-Measures, Carluke, Lanarkshire. *Presented by George Griffiths, Esq.*, 1882.

Genus **CHEIRACANTHUS,** Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1835, p. 125.]

Body fusiform, laterally compressed. Teeth minute or absent; orbit with ring of four circumorbital dermal plates. Pectoral fins large; pelvic pair well developed. A single dorsal fin, arising opposite the space between the pelvic fins and the anal.

Cheiracanthus murchisoni, Agassiz.

1835. *Cheiracanthus murchisoni*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 126, pl. i *c*. figs. 3, 4.
1835. *Cheiracanthus minor*, L. Agassiz, *ibid.* pt. i. p. 127, pl. i *c*. fig. 5.
1844. *Cheiracanthus microlepidotus*, L. Agassiz, Poiss. Foss. V. G. R. p. 38, pl. xv. figs. 1–3. [British Museum and Forres Museum.]
1848. *Chiracanthus lateralis*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 300. [Woodwardian Museum, Cambridge.]
1848. *Chiracanthus pulverulentus*, F. M'Coy, *ibid.* p. 299. [Ibid.]
1855. *Chiracanthus lateralis*, F. M'Coy, Brit. Palæoz. Foss. p. 582.
1855. *Chiracanthus microlepidotus*, F. M'Coy, *ibid.* p. 583.
1855. *Chiracanthus minor*, F. M'Coy, *ibid.* p. 583.
1855. *Chiracanthus murchisoni*, F. M'Coy, *ibid.* p. 583.
1855. *Chiracanthus pulverulentus*, F. M'Coy, *ibid.* p. 583, pl. ii B. fig. 2.
1888. *Cheiracanthus murchisoni*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 512.

Type. Imperfect fish; unknown (*olim* Murchison Collection).

The type species, usually attaining a length of about 0·16–0·2, but occasionally measuring as much as 0·3. Body elongated and slender, the greatest depth being nearly equal to the length of the

head with branchial apparatus, and contained about five times in the total length. Fin-spines slender, the length of the pectorals less than the depth of the trunk at their point of insertion, and the pelvic spines scarcely more than half as long as these. Pelvic fins with much elongated base-line, arising midway between the pectorals and the anal; anal spine about equal in size to the pelvic spines, and the anal fin separated by a considerable space from the caudal. Dorsal fin very large, arising about midway between the pelvic fins and the anal. Scales marked with very fine, straight or irregularly wavy striæ.

Form. & Loc. Lower Old Red Sandstone: Banffshire, Nairnshire, Cromarty, Ross-shire, Caithness, and the Orkney Isles, Scotland.

P. 1355. Two crushed specimens in nodules; Gamrie, Banffshire. *Egerton Coll.*

P. 1355 a–b, P. 3257 a–b. Two split nodules, each containing a crushed and imperfectly preserved fish; Gamrie. *Egerton and Enniskillen Colls.*

36063. Small fish, laterally crushed, showing the pelvic, dorsal, and anal fins, and portions of the pectorals and caudal; Tynet Burn, Banffshire. *Purchased*, 1861.

41412, 41412 a. Small specimen, showing partial impressions of the muscular myotomes, and a fish about 0·17 in length with well-preserved remains of the pectoral, pelvic, and anal fins; Tynet Burn. *Purchased*, 1869.

P. 1356. Three specimens more or less crushed and distorted, one displaying the circumorbital dermal plates; Tynet Burn. *Egerton Coll.*

P. 1356 a, P. 3254. Split nodule with greater portion of a fish wanting the caudal fin; Tynet Burn. In this specimen the cartilages of the jaws and portions of the basipterygium are exhibited. *Egerton and Enniskillen Colls.*

P. 544. Type specimen of *Cheiracanthus microlepidotus*, figured by Agassiz, *loc. cit.* fig. 2; Lethen Bar, near Nairn. *Egerton Coll.*

28865. Two small crushed and contorted fishes, slightly larger than the last; Lethen Bar. *Purchased*, 1854.

P. 1351. Imperfect fish about 0·16 in length; Lethen Bar. *Egerton Coll.*

P. 4614. Remains of a smaller fish, determined by Agassiz as *C. microlepidotus*; Lethen Bar. *Enniskillen Coll.*

P. 4613. Fish, wanting head; Lethen Bar. *Enniskillen Coll.*

P. 5963. Small specimen, showing well-preserved pelvic fins; Lethen Bar. *Purchased*, 1889.

49183. Fish with crushed head, lateral aspect, in counterpart, wanting the caudal fin; Lethen Bar. *Purchased*, 1878.

50105. Specimen originally about 0·26 in length, showing all the fins, but wanting the upper lobe of the tail and portions of the head; Lethen Bar. *Purchased*, 1879.

P. 4039. A well-preserved still larger fish, 0·3 in length; Lethen Bar. *Purchased*, 1883.

19061–63. Three much-crushed imperfect specimens; Cromarty. *Purchased*, 1845.

19801. Two similar fossils; Cromarty. *Purchased*, 1845.

P. 1354. Comparatively well-preserved specimen; Cromarty. *Egerton Coll.*

P. 3256. Imperfect fish, showing all the fins; Cromarty. *Enniskillen Coll.*

43460. Trunk of small fish; Eathie Bay, Ross-shire. *Presented by Kenneth Murchison, Esq.*, 1872.

P. 1353. Crushed specimen and fragment; Edderton, near Tain, Ross-shire. *Egerton Coll.*

P. 186–7. A fine specimen, 0·165 in length, and a small crushed individual displaying the fin-spines; Caithness. *Purchased*, 1881.

35046. Nearly complete fish, preserved in black flagstone and having a bituminous appearance; Stromness, Orkney. *Purchased*, 1860.

38730, 41360. Two similar but larger specimens; Orkney. *Purchased*, 1865, 1869.

39193. Fish wanting head and portion of tail; Skaill, Orkney. *Bowerbank Coll.*

P. 1347–49. Four imperfect specimens; Orkney. *Egerton Coll.*

P. 4475. Small fish in similar state of preservation; Stromness, Orkney. *Enniskillen Coll.*

P. 4476. Two imperfect larger specimens; Belyacreugh, Orkney. *Enniskillen Coll.*

Cheiracanthus latus, Egerton.

1861. *Cheiracanthus latus,* Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 73, pl. x.

1888. *Cheiracanthus latus,* R. H. Traquair, Geol. Mag. [3] vol. v. p. 512.

Type. Nearly complete fish.

A species attaining a length of about 0·16. Body comparatively short and stout, the greatest depth exceeding the length of the head and contained about four times in the total length. Fin-spines stout, the length of the pectorals at least equalling the depth of the trunk at their point of insertion, and the pelvic spines two thirds as long as these. Pelvic fins with elongated base-line, arising midway between the pectorals and the anal; anal spine about equal in size to the pelvic spines, and the anal fin extending to the base of the very large caudal. Dorsal fin as large as the pectorals, arising midway between the pelvic fins and the anal. Scales marked with few large, rounded, parallel ridges and furrows.

Form. & Loc. Lower Old Red Sandstone: Banffshire, Scotland.

The following specimens were all obtained from nodules in Tynet Burn :—

35052. Imperfect fish, wanting the tail. *Purchased,* 1860.

35022–23. Two imperfect crushed specimens. *Presented by the Duke of Richmond,* 1859.

35985. Remains of a large fish. *Purchased,* 1861.

36010, 36062. Two specimens of moderate size. *Purchased,* 1861.

36064–65. Small specimen, in counterpart. *Purchased,* 1861.

37383. Fish wanting the head and the end of the tail. *Purchased,* 1863.

43015–17. Three crushed specimens, the second showing circumorbital plates, and the scales of the third exhibiting traces of fine striations upon the usual coarse ridges and furrows. *Purchased,* 1871.

43273 a–b, 43274. Specimen in counterpart, wanting the head, and a crushed individual with very powerful spines. *Purchased,* 1871.

P. 1350. Four specimens. *Egerton Coll.*

P. 3253. Three specimens. *Enniskillen Coll.*

P. 6075. Imperfect specimen, showing all the spines. *Presented by F. Harford, Esq.,* 1889.

Cheiracanthus grandispinus, M'Coy.

848. *Chiracanthus grandispinus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 300.

1855. *Chiracanthus grandispinus*, F. M'Coy, Brit. Palæoz. Foss. p. 582, pl. ii B. fig. 1.

1888. *Cheiracanthus grandispinus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 512.

Type. Imperfect fish ; Woodwardian Museum, Cambridge.

An imperfectly known species, attaining a length of about 0·25–0·3. Body comparatively deep and robust. Fin-spines extremely stout and longitudinally ribbed, the length of the pectorals not equalling the depth of the trunk at their point of insertion. Pelvic fins arising midway between the pectorals and the anal, and the dorsal midway between the pelvics and the anal. Scales relatively small.

Form. & Loc. Lower Old Red Sandstone : Orkney Isles, Scotland.

39186. Middle portion of trunk, with pelvic, dorsal, and anal spines. *Bowerbank Coll.*

41130. Imperfect head and trunk, wanting the extremity of the caudal region. *Bryson Coll.*

P. 178–9. Two imperfectly preserved specimens, the first showing remains of the head and anterior portion of the abdominal region, the second only wanting the extremity of the tail. *Purchased*, 1881.

Family ISCHNACANTHIDÆ.

Two dorsal fins present, both these and the anal with an anterior spine. Clavicular bones absent.

This family is represented only by the type genus.

Genus **ISCHNACANTHUS,** Powrie.

[Quart. Journ. Geol. Soc. vol. xx. 1864, p. 419.]

Syn. *Ictinocephalus*, D. Page, Rep. Brit. Assoc. 1858, Trans. Sect. p. 104 (undefined).

Body fusiform, laterally compressed. Dentition prominent, consisting of few large conical teeth, the interspaces between these teeth being occupied by a close series of minute cusps, all apparently in firm connection with a membrane-bone in both jaws. No median pair of spines attached to the pectoral arch between the pectoral fin-spines.

This genus was withdrawn by J. Powrie in 1870[1], the type species being assigned to *Diplacanthus*; but it has lately been once more adopted by R. H. Traquair[2].

Ischnacanthus gracilis (Egerton).

[Plate I. fig. 8.]

1859. *Ictinocephalus granulatus*, D. Page, Rep. Brit. Assoc. 1858, Trans. Sect. p. 105 (name only).

1861. *Diplacanthus gracilis*, Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 69, pl. ix.

1864. *Ischnacanthus gracilis*, J. Powrie, Quart. Journ. Geol. Soc. vol. xx. p. 419.

1870. *Diplacanthus gracilis*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 290, pl. x. fig. 2.

1888. *Ischnacanthus gracilis*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 512.

Type. Nearly complete fish.

The type species, attaining a maximum length of about 0·12–0·16. Body slender and elongated, the greatest depth being contained about five times in the total length. Fin-spines slender, coarsely striated longitudinally. Pectoral fin-spines gently arched; no pair of free spines between these and the pelvic fins; pelvic fin-spines about two thirds as large as the pectoral, and placed midway between these and the anal. Dorsal spines nearly equal in size, or the second slightly the larger; first dorsal spine placed well behind the pectorals, second dorsal immediately behind the anal, which is somewhat smaller. Scales smooth. Large dental crowns robust and smooth.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

All the following specimens were obtained from Turin Hill, near Forfar:—

38517. Small example. *Purchased*, 1864.

38598–99. Nearly complete fish, displaying dentition; and an imperfect large specimen, probably exceeding 0·16 in length. *Presented by James Powrie, Esq.*, 1864.

41363–64. Trunk with complete tail, and an imperfect crushed specimen. *Purchased*, 1869.

46303. Imperfect trunk and tail, in counterpart, of an individual probably 0·16 in total length. *Purchased*, 1875.

[1] Trans. Edinb. Geol. Soc. vol. i. (1870) p. 289.

[2] Geol. Mag. [3] vol. v. (1888) p. 512.

46305, 46305 a. Four specimens, two being destitute of the tail; also an imperfect left mandibular ramus with portions of the dentition. *Purchased*, 1875.

P. 132–6, P. 141–2, P. 144–8. Twelve specimens, the first preserved in counterpart and shown, of the natural size, in Pl. I. fig. 8. This specimen appears to exhibit the precise outline of the fish, without distortion, and all the fin-spines are preserved in their natural positions. Two large teeth remain in the upper jaw, but the bones and cartilages of the head are obscure. A series of short, vertically elongated impressions in the anterior portion of the trunk have the appearance of neural arches; though, if so, the head has been somewhat displaced by crushing, for a few of these impressions occur far forwards. The characteristic form of the basal cartilage of one pectoral fin is indistinctly shown. Portions of the membrane of the pelvic and anal fins are exhibited, and the caudal is apparently complete. *Purchased*, 1880.

P. 1344. Two small specimens, and one measuring not less than 0·15 in length. *Egerton Coll.*

The following specimen is not certainly determinable, but appears to pertain to a large individual of this species :—

P. 131. Caudal region and hinder portion of the abdominal region of an Acanthodian fish, the specimen preserved in counterpart and measuring 0·13 in length; Lower Old Red Sandstone, Turin Hill, near Forfar. Remains of the pectoral spines show that these were of moderate size, slender, arched, and finely ribbed. One dorsal spine (presumably the second) is situated slightly behind the anal, and the caudal fin is very robust. The scales are minute, smooth, and faintly hollowed. *Purchased*, 1880.

Family DIPLACANTHIDÆ.

Two dorsal fins present, both these and the anal with an anterior spine. Pectoral arch with clavicular bones.

Synopsis of Genera.

A. Paired spines between pectoral and pelvic fins insignificant or absent.
Teeth minute or absent; median pair of spines between pectorals ..... *Diplacanthus* (p. 23).

B. Paired spines between pectoral and pelvic fins well developed.
Anterior dorsal fin-spine not exceeding the posterior in length ..... *Climatius* (p. 28).
Anterior dorsal fin-spine much exceeding the posterior in length..... *Parexus* (p. 33).

Genus **DIPLACANTHUS,** Agassiz.

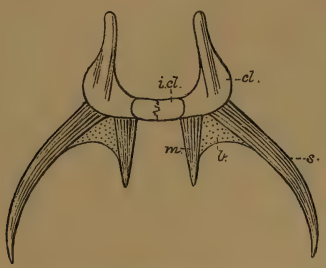
[Poiss. Foss. V. G. R. 1844, pp. 34, 40.]

Syn. *Rhadinacanthus*, R. H. Traquair, Geol. Mag. [3] vol. v. 1888, p. 512.

Body fusiform, probably not much laterally compressed. Teeth minute or absent; orbit with ring of four circumorbital dermal plates. Pectoral fins large, and a median pair of stout spines fixed between these to the basal pterygia; a pair of free spines situated ventrally between the pectoral and pelvic fins.

The pectoral fins in this genus are somewhat difficult of interpretation, but the accompanying woodcut (fig. 3) seems to represent

Fig. 3.



Pectoral arch and fins of *Diplacanthus striatus*, Ag.—*b*, basal cartilage; *cl.* clavicle; *i.cl*, infraclavicle; *m*, median spine; *s*, fin-spine.

the arrangement of the spines and pectoral arch in the type species. As is usually the case in crushed specimens, the fin-spines are exhibited from the dorsal aspect, and the ascending limb of the pectoral arch is bent forwards and exposed from the inner side. The greater portion of the pectoral arch consists of a pair of vertically elongated elements (*cl.*), each having a straight rod-like axis, filled with calcite in the fossil, and thus originally either hollow or occupied by uncalcified tissue; behind this axis there is a thin laminar expansion of bone, diminishing upwards, and apparently extending downwards and inwards to form an inferior limb. The pair of large bones does not meet in the median line below, but is separated by a much smaller pair of bony laminæ (*i.cl.*), united in a finely dentated

mesial suture. Both these elements have precisely the appearance of membrane-bones; and in some genera (e. g. *Parexus*, No. P. 130, p. 35) the conformation of the scales in the pectoral region so intimately depends upon their form and position, that they are evidently of a superficial character. We therefore venture to determine them as clavicles and infraclavicles. The truncated extremity of the pectoral fin-spine (*s.*) directly abuts against the angle of the supposed clavicle, while that of the mesial spine (*m.*) is chiefly apposed to the same element, though in part also to the infraclavicle. The axes of these two spines are inclined towards one another, and at their proximal extremity they are firmly united by a triangular mass of hard tissue (*b*), which is probably to be regarded as the basipterygium or basal cartilage.

Diplacanthus striatus, Agassiz.

1841. "Ichthyolite," H. Miller, Old Red Sandstone, pl. viii. fig. 2.
1842. *Diplocanthus crassisimus*, P. Duff, Geol. Moray, p. 71, pl. x. fig. 2.
1844. *Diplacanthus striatus*, L. Agassiz, Poiss. Foss. V. G. R. pp. 34, 41, pl. xiv. figs. 1–5.
1844. *Diplacanthus striatulus*, L. Agassiz, *ibid.* pp. 34, 42, pl. xiii. figs. 3, 4. [Forres Museum and British Museum.]
1844. *Diplacanthus crassispinus*, L. Agassiz, *ibid.* pp. 34, 43, pl. xiii. figs. 1, 2, pl. xiv. figs. 6, 7. [British Museum, in part.]
1848. *Diplacanthus gibbus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 301. [Woodwardian Museum, Cambridge.]
1855. *Diplacanthus gibbus*, F. M'Coy, Brit. Palæoz. Foss. p. 584, pl. ii B. fig. 4.
1888. *Diplacanthus striatus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 512.

Type. Nearly complete fishes; Edinburgh Museum (in part).

The type species, usually attaining a length of 0·07–0·1. Body robust, but elongated, the greatest depth being contained about four and a half times in the total length. Fin-spines very stout, coarsely striated longitudinally. Pectoral fin-spines much arched and sharply pointed, the median spines relatively large; pelvic fin-spines scarcely half as large as the pectoral. First dorsal spine much stouter and larger than the second, placed almost immediately above the pectoral arch; second dorsal spine opposed to the anal and somewhat larger than the latter. Scales smooth.

Form. & Loc. Lower Old Red Sandstone: Cromarty, Banffshire, Nairnshire, Ross-shire, and Orkney Isles.

19073–74. Imperfect specimen, in counterpart; Cromarty.
Purchased, 1845.

19406, 19802. One specimen displaying the dorsal and anal fin-spines, and four more crushed, imperfect fishes; Cromarty. *Purchased*, 1845.

P. 1360, P. 3260. Fish displaying most of the fin-spines, and a more imperfect specimen in counterpart; Cromarty. *Egerton and Enniskillen Colls.*

P. 4047. Specimen in counterpart, showing fin-spines and second dorsal fin; Gamrie. The median pair of pectoral spines is well shown, and that of the left side is seen to be connected by some intermediate tissue at its base with the outer pectoral spine. *Purchased*, 1883.

41900. Imperfectly preserved fish, lateral aspect, wanting paired spines; Gamrie. *Purchased*, 1870.

P. 543. One of the type specimens of *D. striatulus*, figured by Agassiz, *op. cit.* pl. xiii. fig. 4; Lethen Bar. *Egerton Coll.*

P. 1357a, P. 1364. Two imperfect similar fishes, one ventral, and the other lateral aspect; Tynet Burn. The first specimen exhibits an inner view of the pectoral arch with displaced infraclavicles. *Egerton Coll.*

P. 1366. Fish wanting the head and the extremity of the tail, lateral aspect; Tynet Burn. There are distinct indications of a double series of well-spaced endoskeletal supports in the front part of the lower lobe of the caudal fin. *Egerton Coll.*

35053. A very small specimen, ventral and lateral aspect; Tynet Burn. *Purchased*, 1860.

35987, 36066. Imperfect remains of two fishes; Tynet Burn. *Purchased*, 1861.

36582. Specimen displaying the paired fin-spines from beneath; Tynet Burn. The element connecting the pectoral spine of each side with its adjoining median spine seems to be a superficially calcified cartilage. The interdigitating infraclavicles are seen in position. *Purchased*, 1862.

43275. Small specimen, ventral aspect; Tynet Burn. *Purchased*, 1871.

P. 1173. Imperfect specimen, lateral aspect; Edderton, near Tain. *Egerton Coll.*

P. 177. Imperfect specimen: Orkney. *Purchased*, 1881.

43018. Specimen assigned to *D. crassispinus* by Agassiz, *op. cit.* pl. xiii. fig. 2; Orkney. *Purchased*, 1871.

36327. Imperfect specimen, showing some of the spines; Orkney. *Purchased*, 1862.

39190–91. Two very indistinctly preserved specimens; Skaill, Orkney. *Bowerbank Coll.*

41843–44. Two similar fossils; Orkney. *Purchased*, 1869.

P. 1357–9. Seven specimens, very imperfect; Belyacreugh and Ramna Gio, Orkney. *Egerton Coll.*

P. 3261. Trunk with caudal extremity; Belyacreugh. *Enniskillen Coll.*

Diplacanthus longispinus, Agassiz.

[Plate III. fig. 1.]

1841. "Ichthyolite," H. Miller, Old Red Sandstone, pl. viii. fig. 1.
1844. *Diplacanthus longispinus*, L. Agassiz, Poiss. Foss. V. G. R. pp. 34, 42, pl. xiii. fig. 5, pl. xiv. figs. 8, 9.
1848. *Diplacanthus perarmatus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 301. [Woodwardian Museum, Cambridge.]
1855. *Diplacanthus perarmatus*, F. M'Coy, Brit. Palæoz. Foss. p. 585, pl. ii B. fig. 3.
1888. *Rhadinacanthus longispinus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 512.

Type. Nearly complete fish; Forres Museum.

A large species, attaining a maximum length of about 0·22. Body robust, but elongated, the greatest depth being contained about four and a half times in the total length. Fin-spines much elongated, with at least one longitudinal sulcus parallel to the anterior margin. Pectoral fin-spines about one third larger than the pelvic pair, and the median pectorals relatively small, well separated from the ordinary pectorals; pelvic fins situated much nearer to the anal than to the pectorals. Dorsal fin-spines very large and elongated, the first smaller than the second, placed slightly behind the pectoral arch; second dorsal opposed to the anal and much larger than the latter. Scales marked with prominent radiating furrows and ridges.

This species is regarded as the type of a distinct genus, *Rhadinacanthus*, by Traquair, on the assumption that median pectoral spines are absent. A specimen recorded below (No. P. 4041), however, proves that the spines in question occur in their usual place; and

there is thus no justification for the proposed change in nomenclature.

Form. & Loc. Lower Old Red Sandstone: Nairnshire, Banffshire, Cromarty, and Orkney Isles.

49184. Specimen showing displaced dorsal spines, the anal, and portions of the pectoral arch, in counterpart; Lethen Bar. *Purchased*, 1878.

P. 1362. Fragment, with first dorsal fin; Lethen Bar. *Egerton Coll.*

P. 5076. Imperfect specimen, in counterpart, with pectoral, pelvic, and anal spines, and a fragment of the second dorsal; Lethen Bar. *Presented by J. E. Lee, Esq.*, 1885.

P. 1361. Nodule with imperfect remains of a fish; Gamrie. *Egerton Coll.*

P. 4040. Large, well-preserved specimen, in counterpart, lateral aspect; Gamrie. *Purchased*, 1883.

P. 4041. Smaller fish, in counterpart, shown from the ventral and lateral aspects, and displaying part of the pectoral arch with the median pectoral spines; Gamrie. The specimen is represented, of the natural size, in Pl. III. fig. 1, and the various parts indicated by the lettering. It is of especial interest as exhibiting very distinctly the lower expanded portion of the right side of the pectoral arch, with a short, stout, straight, acute spine, directed backwards from its median end. Unfortunately, however, no precise details of the basipterygium of the pectoral fin can be observed. *Purchased*, 1883.

P. 5075. Nearly complete fish, lateral aspect, in half of nodule; Gamrie. *Presented by J. E. Lee, Esq.*, 1885.

P. 6188. Trunk with fins and part of head, in counterpart; Gamrie. *Purchased*, 1890.

P. 176. Very imperfectly preserved specimen in flagstone; Orkney. *Purchased*, 1881.

P. 1369. Similar fossil; Orkney. *Egerton Coll.*

Genus **CLIMATIUS**, Agassiz.

[Poiss. Foss. V. G. R. 1845, p. 119.]

Syn. *Brachyacanthus*, Sir P. Egerton, Rep. Brit. Assoc. 1859 (1860), Trans. Sect. p. 116.
Euthacanthus, J. Powrie, Quart. Journ. Geol. Soc. vol. xx. 1864, p. 425.

Body fusiform, laterally compressed. Teeth minute or absent. Fin-spines extremely robust, marked with coarse longitudinal ridges, sometimes with posterior denticles; first dorsal spine not excessively elongated; several pairs of free spines on the ventral aspect between the paired fins.

A detached fin-spine only was known to Agassiz, and the precise definition of the genus was first rendered possible by Egerton's discovery of *C. scutiger*.

Climatius reticulatus, Agassiz.

1845. *Climatius reticulatus*, L. Agassiz, Poiss. Foss. V. G. R. p. 120, pl. xxxiii. fig. 26.
1861. *Climatius reticulatus*, Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 68, pl. viii. figs. 11–13.
1864. *Climatius reticulatus*, J. Powrie, Quart. Journ. Geol. Soc. vol. xx. p. 421.
1870. *Climatius reticulatus*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 295, pl. xiii. fig. 10.

Type. Detached fin-spine.

The type species, attaining a maximum length of about 0·2. Body elongated, the greatest depth being contained probably more than five times in the total length; head and branchial apparatus occupying one fourth of the total length. Spines all short and broad, the longitudinal ridges being more or less tuberculated, and the transverse lines of growth at the base usually prominent. Pectoral fin-spines the largest and most elongated, considerably arched, without posterior denticles; four pairs of very short and broad, small, intermediate, ventral spines, of which the hindermost pair is the largest; pelvic fin-spines less than half as large as the pectoral. First dorsal spine shorter, broader, and more curved than the second, situated midway between the pectoral and pelvic pairs; second dorsal spine comparatively straight, slender, and pointed, similar to the anal, and either directly opposed to the latter or immediately in advance of it. Scales relatively large, smooth, or tuberculated.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

38596. Imperfect fish, showing large tuberculated dermal scales upon the head and portions of most of the spines; Turin Hill, Forfar. *Presented by James Powrie, Esq.*, 1864.

P. 137. Imperfect fish, displaying most of the spines; Turin Hill. *Purchased*, 1880.

P. 138–9. Fragment of the head and anterior portion of the trunk of a small fish, preserved in counterpart; also the trunk with pectoral arch and most of the spines of a similar small individual; Turin Hill. *Purchased*, 1880.

P. 1343, P. 1343 a. Imperfectly preserved large fish, about 0·2 in total length, displaying variations in squamation; also a small individual exhibiting more of the spines; Turin Hill. *Egerton Coll.*

P. 584. Counterpart of imperfect second dorsal fin-spine, figured by Egerton, *loc. cit.* fig. 12; Farnell. *Egerton Coll.*

P. 1343 b. Three fragmentary impressions of spines; Farnell. *Egerton Coll.*

Climatius scutiger, Egerton.

1860. *Brachyacanthus scutiger*, Sir P. Egerton, Rep. Brit. Assoc. 1859, Trans. Sect. p. 116.
1861. *Climatius scutiger*, Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 65, pl. viii. figs. 1–10.
1864. *Climatius scutiger*, J. Powrie, Quart. Journ. Geol. Soc. vol. xx. p. 423.
1870. *Climatius scutiger*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 296, pl. xiv. figs. 12, 13.

Type. Nearly complete fishes; British Museum (in part).

A very small species, attaining a maximum length of about 0·06. Body elongated, the greatest depth being contained probably more than five times in the total length; head and branchial apparatus occupying one fifth of the total length. Spines all short and broad, the longitudinal ridges being sometimes tuberculated. Pectoral fin-spines stout and slightly arched, about equal in size to the first dorsal; four pairs of very short and broad, small, intermediate ventral spines; pelvic fin-spines about half as large as the pectoral. First dorsal spine shorter, broader, and more curved than the second, situated midway between the pectoral and pelvic pairs; second dorsal spine comparatively straight, slender, and pointed, slightly more remote and much larger than the anal. Scales mostly small,

smooth or externally sculptured; a single series of somewhat larger ridge-scales between the occiput and the first dorsal fin.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

35907–8. Two fine specimens, the second measuring not more than 0·035 in length and exhibiting the extremely attenuated tail; Farnell. *Presented by James Powrie, Esq.*, 1861.

P. 561–2. Two of the type specimens, figured by Egerton, *loc. cit.* (1861), pl. viii. figs. 2, 3; Farnell. *Egerton Coll*

P. 1341. Fish wanting the extremity of the caudal region; also a fragment of the head and abdominal region; Farnell. *Egerton Coll.*

P. 3263. Two small specimens; Farnell. *Enniskillen Coll.*

Climatius uncinatus, Powrie.

1864. *Climatius uncinatus*, J. Powrie (*ex* Egerton, MS.), Quart. Journ. Geol. Soc. vol. xx. p. 422.

1870. *Climatius uncinatus*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 296, pl. xiv. fig. 11.

Type. Fish; collection of James Powrie, Esq., Reswallie.

A small species, attaining a maximum length of about 0·1. Body elongated; head and branchial apparatus occupying about one fifth of the total length. Spines broad, but elongated. Pectoral fin-spines the largest, considerably arched, with large posterior denticles; four pairs of short and broad, small, intermediate ventral spines; pelvic fin-spines about half as large as the pectoral. First dorsal spine straight, almost identical with the second; the latter somewhat larger than the anal and placed slightly in advance of this.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

P. 1342. Imperfect specimen, showing portions of denticulated pectoral spines; Turin Hill, near Forfar. *Egerton Coll.*

Climatius macnicoli (Powrie).

1864. *Euthacanthus mcnicoli*, J. Powrie, Quart. Journ. Geol. Soc. vol. xx. p. 425, pl. xx. fig. 2.

1870. *Euthacanthus m'nicoli*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 290, pl. xi. fig. 3.

1890. *Climatius macnicoli*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 36.

Type. Complete fish; collection of James Powrie, Esq., Reswallie.

A species of large size, about 0·17 in maximum length. Body

elongated, the greatest depth being contained more than five times in the total length. Spines comparatively straight and narrower than in the type species; longitudinal ridges usually smooth. Pectoral fin-spines straight, scarcely larger than the first dorsal; five pairs of intermediate ventral spines, separated by a distinct interval from the pelvic fin-spines; the latter at least two thirds as long as the pectoral pair. First dorsal spine shorter and stouter than the second, situated midway between the pectoral and pelvic pairs; second dorsal spine very slightly in advance of the anal, about equal to this in size. Scales smooth.

This is the type species of *Euthacanthus*, Powrie.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

P. 1337. Imperfectly preserved trunk, wanting the head and tail, but exhibiting the situation and proportions of the spines; Forfar. *Egerton Coll.*

Climatius grandis (Powrie).

1870. *Euthacanthus grandis*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 292, pl. xii. fig. 6.

Type. Fragments of fish; collection of James Powrie, Esq., Reswallie.

A very large species, attaining a maximum length of not less than 0·6 (according to Powrie). Body much elongated. Spines comparatively straight and narrower than in the type species; longitudinal ridges usually smooth. Pectoral fin-spines straight, probably about equal to the first dorsal in size; not less than four pairs of intermediate ventral spines, separated by a distinct interval from the pelvic fin-spines; the latter at least two thirds as long as the pectoral pair. First dorsal spine smaller than the second, situated somewhat nearer to the pectoral than the pelvic pair; second dorsal spine slightly in advance of the anal, and much larger than the latter. Scales of the flank in the abdominal region ornamented with a few short horizontal striæ in the anterior half; other scales mostly smooth.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

38597. Crushed trunk of small individual, wanting head and extremity of the tail, showing four pairs of intermediate ventral spines and portions of the pelvic, anal, and dorsal fin-spines; Turin Hill, Forfar.

Presented by James Powrie, Esq., 1864.

P. 129. Small individual, wanting the head, preserved in counterpart; Turin Hill. Portions of all the spines are shown.
Purchased, 1881.

P. 128. Hinder portion of abdominal region and caudal region of a fish measuring 0·18 from the second dorsal spine to the extremity of the tail, preserved in counterpart; Turin Hill. In addition to the scales this specimen exhibits the pelvic, second dorsal, and fragmentary anal spines.
Purchased, 1880.

Climatius gracilis (Powrie).

1870. *Euthacanthus gracilis*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 291, pl. xi. fig. 4.

Type. Fish wanting head and anterior half of abdominal region; collection of James Powrie, Esq., Reswallie.

A species about 0·2 in length. Body much elongated; spines comparatively straight. Four or five pairs of intermediate ventral spines, separated by a distinct interval from the pelvic fin-spines; the latter more than half as long as the anal spine. First dorsal spine shorter than the second, about midway between the pectoral and pelvic pairs; second dorsal spine much larger than the anal, well in advance of the latter, almost opposed to the pelvic spines. Lateral line with double series of enlarged scales. (*Powrie.*)

Form. & Loc. Lower Old Red Sandstone: Farnell, Forfarshire.

Not represented in the Collection.

The so-called *Euthacanthus elegans*, Powrie (*tom. cit.* 1870, p. 292, pl. xii. fig. 5), is founded upon an imperfect impression of a fish from Farnell, only differing from *Climatius gracilis* in the proportions of some of the spines, which may be imperfectly shown. Another species, *Euthacanthus curtus*, Powrie (*ibid.* p. 293, pl. xii. fig. 7), from Turin Hill and Farnell, does not appear to belong to this genus, and is doubtfully referred to *Diplacanthus* by Woodward and Sherborn, Cat. Brit. Foss. Vertebrata (1890), p. 65. The type specimens are in the collection of James Powrie, Esq.

Climatius (?) ornatus (Agassiz).

1837. *Ctenacanthus ornatus*, L. Agassiz, Poiss. Foss. vol. iii. p. 12, pl. ii. fig. 1.

1845. *Ctenacanthus ornatus*, L. Agassiz, Poiss. Foss. V. G. R. pp. 111, 119.

1857. "Ichthyodorulites," Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xiii. p. 288, pl. x. figs. 5, 7.

Type. Fragment of spine.

An undefined species known only by fragments of fin-spines more closely resembling those of *Climatius* than of any other genus. The longitudinal ridges upon the spine are notched, the intervals being very short immediately above the base, and at least twice as long as these throughout the more distal portion.

Form. & Loc. Lower Old Red Sandstone (Passage Beds): Herefordshire and Worcestershire.

P. 5092. Two imperfect spines; Tin Mill, Downton, near Ludlow. *Presented by J. E. Lee, Esq.*, 1885.

Climatius (?) latispinosus (Whiteaves).

1881. *Ctenacanthus latispinosus*, J. F. Whiteaves, Canadian Naturalist, n. s. vol. x. p. 99.

1889. *Ctenacanthus latispinosus*, J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 95, pl. x. fig. 3.

1889. *Climatius latispinosus*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. iv. p. 183.

Type. Detached fin-spines; Geological Survey of Canada, Ottawa.

An undefined species known only by detached fin-spines, which attain a relatively large size. The spines are broad, nearly straight, with finely tuberculated ridges and prominent posterior denticles.

Form. & Loc. Lower Devonian: Campbellton, New Brunswick.

P. 6223. Imperfect spine. *Presented by the Director of the Geological Survey of Canada*, 1890.

A doubtful spine is also described as follows:—

Climatius aculeatus, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1602, pl. lvii. fig. 20.—Old Red Sandstone; Slawjanka, near Pawlowsk, St. Petersburg. [University of St. Petersburg.]

Genus **PAREXUS,** Agassiz.

[Poiss. Foss. V. G. R. 1845, p. 120.]

Body deeply fusiform, laterally compressed; caudal fin large and powerful. Teeth minute or absent. Fin-spines robust, marked with coarse longitudinal ridges; first dorsal spine enormously developed, with large posterior denticles; several pairs of free spines on the ventral aspect between the paired fins.

The first dorsal fin-spine only was known to Agassiz, and the genus thus remained imperfectly defined until 1864, when Powrie discovered a complete example of the type species.

Parexus incurvus, Agassiz.

1845. *Parexus incurvus*, L. Agassiz, Poiss. Foss. V. G. R. p. 120, pl. xxxiii. figs. 26, 27.
1864. *Parexus incurvus*, J. Powrie, Quart. Journ. Geol. Soc. vol. xx. p. 424, pl. xx. fig. 1.
1870. *Parexus incurvus*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 293, pl. xii. fig. 8.

Type. Imperfect first dorsal fin-spine.

The type species, attaining a maximum length of about 0·16, but usually much smaller; head occupying one fourth of the total length. Fin-spines with crenulated ridges. Pectoral fin-spines short, stout, and curved; not less than four pairs of short and broad, small, intermediate ventral spines; pelvic fin-spines about two thirds as long as the pectorals, much less robust. First dorsal spine straight or only slightly curved, at least half as long as the complete fish, situated immediately above the pectoral arch, with few, widely spaced, upwardly directed, posterior denticles; second dorsal spine about one third as long as the first, placed immediately in advance of the anal, which it somewhat exceeds in size. Scales externally tuberculated.

In this species the first dorsal fin is shown to be very small in proportion to the size of the spine, while the second dorsal fin extends to the apex of its spine.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

38593. Contorted fish, showing portions of all the fin-spines and the second dorsal and caudal fins; Turin Hill, near Forfar. *Presented by James Powrie, Esq.*, 1864.

P. 127. Imperfect small fish, wanting the caudal fin; Turin Hill. The ornamentation and posterior denticles of the first dorsal spine are well exhibited. *Purchased*, 1880.

P. 1338. A specimen nearly similar to the last, and a more imperfectly preserved fish, displaying the dermal scales and plates of the head; Turin Hill. *Egerton Coll.*

P. 1339–40. Three imperfect impressions of the first dorsal spine; Farnell. *Egerton Coll.*

Parexus falcatus, Powrie.

1870. *Parexus falcatus*, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. p. 294, pl. xiii. fig. 9.

Type. Well-preserved fish; collection of James Powrie, Esq., Reswallie.

A species of larger size than *P. incurvus*; head very large, occupying one third of the total length. Pectoral fin-spines short, stout, and curved; four pairs of short and broad, small, intermediate ventral spines; pelvic fin-spines about two thirds as long as the pectorals, much less robust. First dorsal spine very stout and much curved, with few, widely spaced, posterior denticles, about one third as long as the complete fish and situated immediately above the pectoral arch; second dorsal spine about one half as long as the first, placed immediately in advance of the anal, which it somewhat exceeds in size. Scales externally tuberculated.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

P. 130. Imperfect fish, wanting the head, the extremity of the tail, and the first dorsal fin-spine; Turin Hill, near Forfar. The abdominal region is shown from the ventral, and the caudal region from the lateral aspect. The pectoral arch

Fig. 4.

Pectoral fin and half of pectoral arch of *Parexus falcatus*, Powrie.—*b*, basal cartilage; *cl*, clavicle; *s*, spine.

and spines are shown from beneath, and the elements of the left side are represented in a somewhat diagrammatic manner in the accompanying woodcut. The pectoral arch consists of a pair of thin, triangular or sickle-shaped elements (fig. 4, *cl*), meeting in the middle line, and the inferior limb apparently as large as the ascending limb; as shown in the figure, the latter is crushed so as to be directed backwards. The squamation on the ventral aspect between the pectoral fins is much enlarged and covers an anteriorly narrowing triangular area to the point of meeting of the two halves of the pectoral arch in the median line; and this arrangement of the scales in direct relation to the latter suggests that the elements preserved fall within the category of membrane-bones (clavicles).

The basal cartilage (*b*) of the fin is evidently almost as long as the upper part of the supposed clavicle, with a very broad, triangular, distal extremity, meeting the obliquely truncated, attached end of the pectoral spine (*s*), and terminating in a very slender, rounded, proximal half. The fin-membranes are shown both in connection with this and all the other fin-spines; and there are four pairs of broad, intermediate ventral spines, increasing in size posteriorly. *Purchased*, 1880.

Subclass II. HOLOCEPHALI.

Skeleton cartilaginous, membrane-bones absent. Mandibular suspensorium and upper jaw fused with the cranium. Exoskeleton, when present, structurally identical with the teeth. In the living forms—optic nerves not decussating, bulbus arteriosus of the heart with three series of valves, intestine with a spiral valve, and ovaries with few large ova.

Order CHIMÆROIDEI.

Notochord persistent or partially constricted, the calcifications in the sheath, when present, consisting of slender rings more numerous than the neural and hæmal arches. Pectoral fins shortened, without segmented axis; pelvic fins produced into a pair of claspers in the male. In the living forms—a fold of skin covering the gill-clefts, and leaving a single external opening to the gill-cavity.

In all the known families of Chimæroids, the dentition consists of few large plates of vascular dentine, of which certain areas ("tritors") are specially hardened by the deposition of calcareous salts within and around groups of medullary canals, which rise at right angles to the functional surface. In most cases there is a single pair of such plates in the lower jaw, meeting at the symphysis, while two pairs are arranged to oppose these above. As a whole, the dentition thus closely resembles that of the typical Dipnoi (as has often been pointed out); and the upper teeth may be provisionally named palatine and vomerine until further discoveries shall have revealed their precise homologies. The structures are sometimes described as "jaws," and regarded as dentaries, maxillæ, and premaxillæ, but the presence of a permanent pulp

under each tooth[1] is conclusive proof of their bearing no relation to the familiar membrane-bones thus named in higher fishes.

Synopsis of Families.

I. [Imperfectly defined. Spines unknown.]
One pair of dental plates above and below ..... PTYCTODONTIDÆ (p. 37).

II. Dorsal fin-spines absent. Rostral spine in male.
Trunk depressed, snout elongated. Two pairs of dental plates above, one pair below ..... SQUALORAIIDÆ (p. 40).

III. Spine in front of anterior dorsal fin. Rostral spine in male.
Few dermal plates on head. Two pairs of dental plates above, one pair and an anterior azygous tooth below ..... MYRIACANTHIDÆ (p. 43).
No dermal plates. Two pairs of dental plates above, one pair below ..... CHIMÆRIDÆ (p. 52).

Family PTYCTODONTIDÆ.

A family at present indefinable, of doubtful ordinal position, known only by remains of the dentition. A single pair of large, laterally compressed, dental plates in each jaw, meeting at the symphysis and with few tritoral areas.

The genera of this family have not hitherto been defined, even so far as existing materials will permit. There are as yet no examples of the teeth in the collection of the British Museum; but an examination of a large number of Russian specimens in St. Petersburg, American specimens in New York, recently discovered examples from Canada in the Geological Survey Collection at Ottawa, and several undescribed forms from the Eifel Devonian in the Museum of Comparative Zoology, Cambridge (Mass.), has suggested to the writer the following provisional arrangement.

Synopsis of Genera.

I. Symphysial surface narrow; tritors more or less laminated.
Oral surface triturating, the tritors being well differentiated and consisting of hard, punctate, superimposed laminæ, arranged obliquely to the functional surface ..... *Ptyctodus*, Pander.

[1] R. Owen, Odontography, p. 65.

Oral surface forming a narrow oblique knife-edge, with no differentiated tritors, but having a lamellar-punctate structure within the outer wall ..... *Rhynchodus*, Newberry.

II. Symphysial surface relatively very broad; tritors punctate.

Oral surface triturating, with a single indefinite tritoral area ..... *Palæomylus*, gen. nov.

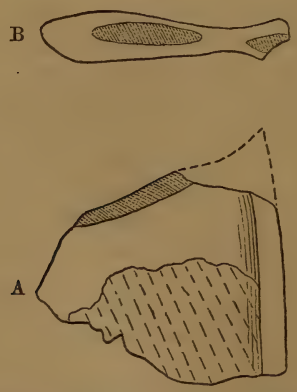
Genus **PTYCTODUS**, Pander.

[Ctenodipt. devon. Syst. 1858, p. 48.]

Syn. *Aulacosteus*, E. von Eichwald, Geognosy of Russia (in Russian), 1846 (according to Leth. Rossica, vol. i. 1860, p. 1548).
Rinodus, Newberry & Worthen, Pal. Illinois, vol. ii. 1866, p. 106.

In this genus the tritoral areas are so much harder than the rest of the tooth that they are often preserved in a rolled state after the removal of the surrounding tissue. Such is the condition of all specimens hitherto described, except the originals of Pander's pl. viii. figs. 10, 12, which exhibit the symphysial region. Specimens in the School of Mines, St. Petersburg, the University of St. Petersburg, and in the Museum of Comparative Zoology, Cambridge (Mass.), prove that the teeth always assumed the form noted above in the diagnosis of the family. A diagrammatic sketch of a tooth in the

Fig. 5.



Tooth of *Ptyctodus obliquus*, Pander, nat. size; Devonian, Russia.—A, inner aspect, showing symphysis, the base enveloped in matrix. B, oral aspect, the tritors marked by transverse lines.

first-mentioned museum, showing the inner and oral aspects, is given in the accompanying woodcut (fig. 5).

The following species are recognized :—

Ptyctodus calceolus, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 59, pl. lix. fig. 13 : *Rinodus calceolus*, Newberry & Worthen, Pal. Illinois, vol. ii. (1866), p. 106, pl. x. fig. 10.—Hamilton Group (Upper Devonian); Illinois and Iowa. [Abraded tooth, the type species of *Rinodus*.]

Ptyctodus obliquus, C. H. Pander, Ctenodipt. devon. Syst. (1858), p. 64, pl. viii. figs. 1–9, 11, 13–22 : *Ptyctodus ancinnatus*, C. H. Pander, *ibid.* p. 64, pl. viii. figs. 10, 12 : *Aulacosteus cochleariformis* and *A. oviformis*, E. von Eichwald, Leth. Rossica, vol. i. (1860), pp. 1548, 1550, pl. lvii. fig. 8.—Middle Devonian; Governments of St. Petersburg, Novgorod, and the Baltic Provinces. [Abraded teeth ; School of Mines, St. Petersburg. The type species.]

Genus **RHYNCHODUS**, Newberry.

[Rep. Geol. Surv. Ohio, vol. i. pt. ii. 1873, p. 307.]

In the type species of this genus, four teeth have been found associated in a group, suggesting that those of the upper and lower jaws were similar, a single pair occurring in each.

The following species are known :—

Rhynchodus excavatus, J. S. Newberry, Rep. Geol. Surv. Wisconsin, vol. ii. (1877), p. 397, and Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 50, pl. xxix. fig. 1.—Hamilton Group (Upper Devonian); Milwaukee, Wisconsin.

Rhynchodus occidentalis, J. S. Newberry, Ann. New York Acad. Sci. vol. i. (1878), p. 192.—Hamilton Group; Iowa. [Columbia College, New York.]

Rhynchodus secans, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 310, pl. xxviii. fig. 1, pl. xxix. figs. 1, 2, and Palæoz. Fishes N. America (1889), p. 47, pl. xxviii. figs. 1–3.—Corniferous Limestone (Middle Devonian); Ohio. [The type species, Columbia College.]

Rhynchodus, sp. ind. : *Physichthys hoeninghausii*, H. von Meyer, Palæontogr. vol. iv. (1855), pl. xv. fig. 9 (*errore*).—Devonian; Eifel, Germany. [Museum of Comparative Zoology, Cambridge, Mass.]

Genus **PALÆOMYLUS**, nov.

In the type species of this genus (*P. frangens*) the symphysis is as broad as in *Edaphodon*.

The following species are placed here:—

Palæomylus crassus: *Rhynchodus crassus*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 312, pl. xxix. fig. 3, and Palæoz. Fishes N. America (1889), p. 49, pl. xxviii. fig. 4.—Corniferous Limestone; Ohio. [Columbia College, New York.]

Palæomylus frangens: *Rhynchodus frangens*, J. S. Newberry, *op. cit.* (1873), p. 311, pl. xxviii. figs. 2, 3, and *op. cit.* (1889), p. 48, pl. xxix. figs. 2, 3.—Corniferous Limestone; Ohio. [Columbia College.]

Palæomylus greenei: *Rhynchodus greenei*, J. S. Newberry, *op. cit.* (1889), p. 51.—Hamilton Group; Milwaukee, Wisconsin.

Family SQUALORAIIDÆ.

Body depressed, but elongated. Head produced into a flat rostrum, without lateral teeth. Dentition consisting of thin, transversely curved plates, without differentiated tritoral areas; a single pair in the lower jaw, meeting at the symphysis, and two pairs in the upper jaw, the hinder pair being closely apposed in the median line anteriorly, but divergent posteriorly. Dorsal fin-spine absent. Males with a prehensile spine upon the snout.

Genus **SQUALORAJA**, Riley.

[Proc. Geol. Soc. vol. i. 1833, p. 484.]

Syn. *Spinacorhinus*, L. Agassiz, Poiss. Foss., Feuill. 1837, p. 94.

Rostrum much produced; tail gradually tapering to a point. [Median fins unknown.] Teeth marked with a series of hard, parallel, longitudinal corrugations; rostral spine of male slender and pointed, with expanded base and a cluster of large recurved denticles on the inferior aspect near its insertion; dermal tubercles conical, radiately sculptured, sparsely arranged. Vertebral rings well calcified, consisting of several concentric lamellæ.

This genus has hitherto been regarded as a Selachian, though the Chimæroid resemblance of its rostral region, the supports of its lateral line, &c., have been pointed out by W. Davies and the present writer. The skulls recorded below have a hyostylic appearance; but the writer is indebted to Dr. R. H. Traquair for the information that the Edinburgh Museum acquired a specimen some years ago proving the arrangement to be truly autostylic, while a pair of vomerine teeth occurs in advance of the well-known large dental

plates already described in the upper jaw. A recent examination of this unique fossil in Edinburgh has convinced the writer of the correctness of Dr. Traquair's determination of the affinities of the fish.

Squaloraja polyspondyla, Agassiz.

[Plate III. fig. 2.]

1833. *Squaloraia dolichognathos*, H. Riley, Proc. Geol. Soc. vol. i. p. 484 (specific name inappropriate).
1837. *Squaloraia dolichognathus*, H. Riley, Trans. Geol. Soc. [2] vol. v. p. 83, pl. iv.
1836. *Spinacorhinus polyspondylus*, L. Agassiz, Poiss. Foss. vol. iii. pls. xlii., xliii., and Feuill. p. 94.
1843. *Squaloraja polyspondyla*, L. Agassiz, *ibid.* vol. iii. p. 381.
1872. *Squaloraja polyspondyla*, W. Davies, Geol. Mag. vol. ix. p. 145, pl. iv.
1885. *Squaloraja polyspondyla*, C. Hasse, Palæontogr. vol. xxxi. p. 4, pl. i. figs. 2, 3.
1886. *Squaloraja polyspondyla*, A. S. Woodward, Proc. Zool. Soc. p. 527, pl. lv. figs. 1–5, 7, 8, and *ibid.* 1887, p. 481.

Type. Imperfect skeleton; Bristol Museum.

The type species, usually not exceeding 0·45 in length. Head occupying more than one third of the total length; distance between pectoral and pelvic arches two thirds as long as the head; caudal region attenuated. Rostral spine of male slender, depressed oval in section, terminating bluntly and not excessively attenuated, occupying more than three quarters the length of the rostral cartilage; claspers of male robust, with a small distal cluster of slender recurved hooklets. Dermal tubercles sparse, a regular series of prominent hooklets on each lateral margin of the tail. Mandibular and palatine teeth about six and a half times as long as their maximum breadth, the symphysial portion somewhat raised and tumid.

Form. & Loc. Lower Lias: Dorsetshire.

The following specimens were all obtained from the Lower Lias of Lyme Regis.

43307. Head, vertebral column, and fragments of pelvic fins, described and figured by W. Davies, *loc. cit.*
Purchased, 1872.

P. 2276. The nearly complete skeleton of a male, wanting only a small portion of the caudal region; described and figured by the present writer, *loc. cit.* *Purchased*, 1882.

P. 2079. Portions of vertebral column and crushed cranium of an old individual, probably female; vertebra figured by the present writer, *loc. cit.* pl. lv. fig. 8. *Egerton Coll.*

P. 3184. Portion of skeleton of young female, ventral aspect, described and figured by the present writer, *loc. cit. passim*, pl. lv. figs. 3, 4, 7. *Enniskillen Coll.*

47402. Skull of male, dorsal aspect; described and figured by the present writer, *loc. cit.* pp. 532, 534, pl. lv. fig. 2. *Purchased*, 1876.

41354. Portion of rostral cartilage; described and figured by W. Davies, *loc. cit.* p. 147, pl. iv. fig. 2. *Purchased*, 1869.

41353. Portion of cranium of female, seen from below; described and figured by W. Davies, *loc. cit.* p. 148, pl. iv. fig. 4. *Purchased*, 1869.

43970. Detached dental plate, shown, of the natural size, in Pl. III. fig. 2. As proved by other specimens, each ramus of the jaw was provided with a single plate of this character. The efficiency of the grinding-surface is increased by a series of parallel longitudinal ridges, which represent the tritors and are distinctly worn down towards the outer functional border. *Purchased*, 1872.

Some of the following specimens may belong to other species:—

P. 6220. Imperfect rostral spine; described and figured by W. Davies, *loc. cit.* p. 148, pl. iv. fig. 3. *Purchased.*

P. 3186. Imperfect rostral spine; described and figured by the present writer, *loc. cit.* p. 531, pl. lv. fig. 5. *Enniskillen Coll.*

P. 3187. Complete, much-curved rostral spine, exhibiting only dorsal aspect. *Enniskillen Coll.*

P. 4574. Anterior two thirds of very large rostral spine. *Enniskillen Coll.*

P. 4323. Two fragmentary abraded rostral spines. *Enniskillen Coll.*

P. 2080. Broken fragment of vertebral column, showing longitudinal section of vertebræ. *Egerton Coll.*

P. 3185, P. 4323 a. Fragments of vertebral column and incomplete rostral spine. *Enniskillen Coll.*

41278. Vertebræ of very small individual. *Purchased*, 1869.

Squaloraja tenuispina, A. S. Woodward.

1886. *Squaloraja tenuispina*, A. S. Woodward, Proc. Zool. Soc. p. 530, pl. lv. fig. 6.

Type. Detached rostral spine; British Museum.

A small species known only by the rostral spine, which is slender and extremely acuminate.

Form. & Loc. Lower Lias: Lyme Regis, Dorsetshire.

P. 2081. Type specimen. *Egerton Coll.*

Genus **CHALCODUS**, Zittel.

[Handb. Palæont. vol. iii. 1887, p. 72.]

A genus probably referable to the Squaloraiidæ and known only by the dentition. Coronal surface of teeth smooth or finely punctate.

Chalcodus permianus, K. A. von Zittel, Handb. Palæont. vol. iii. (1887), p. 72, woodc. fig. 66.—Kupferschiefer; Glücksbrunn Thuringia. [Associated dental plates; Palæontological Museum, Munich.] The type and only known species.

Family MYRIACANTHIDÆ.

Body elongated; anterior dorsal fin above the pectorals, provided with a long, straight, robust spine. Teeth forming two (? or three) pairs of thin dental plates in the upper jaw, the hinder pair attenuated mesially and not closely apposed in the median line; lower dentition consisting of a pair of large dental plates, meeting at the symphysis, and a median incisor-like tooth in front. A few dermal plates present upon the head. Males with a large prehensile spine upon the snout.

Synopsis of Genera.

Palatine teeth larger than the vomerine ..... *Myriacanthus* (p. 43).
Palatine teeth smaller than the vomerine ..... *Chimæropsis* (p. 51).

Genus **MYRIACANTHUS**, Agassiz.

[Poiss. Foss. vol. iii. 1837, p. 37.]

Syn. *Prognathodus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xxviii. 1872, p. 236.
Metopacanthus, K. A. von Zittel, Handb. Palæont. vol. iii. 1887, p. 110.

Rostral cartilage somewhat produced, bearing a terminal cutaneous flap. Mandibular tooth more or less massive in external appearance, though really a thin plate; symphysial surface narrow; oral surface undulating and covered by an extended, punctate, tritoral area, almost or quite continuous. Presymphysial tooth vertically elongated, bilaterally symmetrical, compressed antero-posteriorly, the inner aspect being flat or concave, the outer aspect convex. Palatine tooth thin, plate-like, triangular or irregularly quadrate in form, the outer margin being nearly straight, sharply deflected and thickened, the inner and posterior margins tapering gradually to a thin edge; oral aspect with a continuous, punctate, tritoral area. Vomerine tooth smaller than the palatine, of triangular form, broad posteriorly, and provided either with a long anteriorly-directed process or with a distinct small tooth in front; punctate tritoral area subdivided into rounded patches. Dorsal fin-spine long and slender, somewhat laterally compressed, with a large internal cavity; sides more or less ornamented with small tubercles; a series of large, thorn-shaped, spinous tubercles arranged along each edge of the flattened posterior face, passing into a single median row distally, and a single series of similar denticles occupying at least part of the anterior border. Rostral spine of male elongated and pointed, with expanded base. Dermal plates tuberculated.

Myriacanthus paradoxus, Agassiz.

[Plate II. figs. 1–3.]

1822. "External defensive organ," H. T. De la Beche, Trans. Geol. Soc. [2] vol. i. p. 44, pl. v. figs. 1, 2.

1837. *Myriacanthus paradoxus*, L. Agassiz, Poiss. Foss. vol. iii. p. 38, pl. vi.

1837. *Myriacanthus retrorsus*, L. Agassiz, *ibid.* p. 39, pl. viii *a*. figs. 14, 15. [Base of spine; Oxford Museum.]

1843. *Chimæra* (*Ischyodon*) *johnsonii*, L. Agassiz, *ibid.* p. 344, pl. xl *c*. fig. 22. [Dentition; British Museum.]

1872. *Prognathodus guentheri*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xxviii. p. 233, pl. viii. [Dentition; British Museum.]

1889. *Myriacanthus paradoxus*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. iv. p. 279.

Type. Dorsal fin-spines; British Museum and Bristol Museum.

The type species, of large size, the dorsal spine attaining a maximum length of not less than 0·6. Dorsal spine oval in section, flattened posteriorly, and with a faint anterior longitudinal ridge; lateral tuberculations relatively large and sparse, arranged on a longitudinally striated surface; anterior and posterior denticles very

broad, laterally compressed and pointed, irregularly and widely spaced, occasionally present on part of the longitudinal median line of the posterior face; a few of the posterior denticles distally directed downwards, the others pointing upwards. Hinder upper tooth about twice as long as its maximum breadth. Maximum thickness of presymphysial tooth about one third its breadth, and more than twice as great as the thickness of the inner layer of dentine, which is continuous and uniform; outer face of the tooth gently convex, the inner face slightly concave, but nearly flat.

The genus *Prognathodus* was founded upon the dentition of this species.

Form. & Loc. Lower Lias: Lyme Regis, Dorsetshire.

(i.) *Dorsal Spines.*

P. 6095. One of the type specimens of *Myriacanthus paradoxus*, figured by Agassiz, *tom. cit.* pl. vi. figs. 1, 2, and previously figured, without name, by De la Beche, *loc. cit.*
Old Collection.

P. 3067. Another of the type specimens, figured by Agassiz, *ibid.* pl. vi. fig. 3. *Enniskillen Coll.*

P. 3174. A very large crushed spine, about 0·65 in total length. The slender, compressed distal extremity is preserved, destitute of tubercles for a short extent; and immediately below this space are remains of a few of the characteristic large posterior denticles. At about the middle of the spine, some of the last-mentioned denticles are unbroken, showing their acutely pointed, upwardly curved form.
Enniskillen Coll.

P. 3068, P. 3196. The greater portion of two equally large spines, the first being almost uncrushed and displaying several of the denticles. *Enniskillen Coll.*

P. 1736. Much crushed similar specimen. *Egerton Coll.*

P. 6179. Imperfect large spine, with denticles. *Purchased*, 1890.

P. 6221. Fragments of a very large spine, showing part of the smooth distal extremity.

P. 3071. Distal half of a somewhat smaller spine, with well-preserved denticles. *Enniskillen Coll.*

P. 1737. Similar, but more imperfectly preserved specimen.
Egerton Coll.

P. 3069. Remains of distal two thirds of spine, showing part of the posterior face. For some distance from the pointed extremity this face is flattened or transversely concave, but more proximally a faint median longitudinal ridge begins to appear, bearing one or two denticles at wide intervals. *Enniskillen Coll.*

P. 3197, P. 3197 a, P. 4454 a. The distal half and two portions of the distal half of small spines. The third specimen shows some of the downwardly pointing posterior denticles, and the non-tuberculated apical portion is very short.
Enniskillen Coll.

P. 341. Distal half of small spine, showing denticles.
Purchased, 1881.

P. 427. Fragment of small spine, showing denticles.
Purchased, 1882.

37376. Fragment of small spine, showing denticles.
Purchased, 1863.

41321. Fragment of large spine, showing denticles.
Purchased, 1869.

(ii.) *Dentition.*

P. 477. Type specimen of the so-called *Ischyodus johnsoni*, briefly described, with an imperfect figure, by Agassiz, *loc. cit.* The presymphysial tooth ("intermaxillaire," Agassiz) lies between the two mandibular teeth ("maxillaires supérieurs," Agassiz), of which that of the right side is almost destroyed. One of the palatine teeth ("maxillaire inférieur gauche," Agassiz) is also exposed, from the oral aspect, but its outline is partly obscured or broken away. None of the teeth can be removed from the matrix, owing to its hardness, and they are not arranged so as to permit of the satisfactory drawing of the entire specimen; the characteristic left mandibular tooth is, however, shown from the oral aspect in Pl. II. fig. 3. The symphysial facette of this tooth is narrow, and in the middle of the oral face there is a broad prominence, separated from the symphysial and post-oral margins by deep depressions; the extended, tubulated, tritoral area seems to have been continuous over the oral face, though rapidly thinning towards the outer margin and evidently originally covered with a stratum of hard dentine upon the inner face. The presymphysial tooth seems to have been bilaterally symmetrical, the tritoral portion forming a thick layer upon the

slightly concave inner face, and consisting of tubules arranged at right angles to that face (Pl. II. fig. 2 *b*). The palatine tooth, so far as preserved, exhibits a gently tumid oral surface, completely covered by the tritoral area, which is again enveloped by a thin layer of hard dentine inwardly. *Egerton Coll.*

P. 4664. Type specimen of *Prognathodus guentheri*, described and figured by Egerton, *loc. cit.* The fossil exhibits the anterior aspect of the mandible and all the teeth, except the right palatine, the mouth being opened and the upper dentition displayed from the oral aspect. The mandibular cartilage is flattened, so that both rami lie in one plane, and there is no suture at the symphysis. Two small labial cartilages rest upon its median portion, and at the left extremity is a triangular dermal plate, ornamented with tubercles and provided with two large marginal processes, as shown in Egerton's figure. The dentition is re-figured in the accompanying Pl. II. fig. 1. The mandibular teeth ("maxillary," Egerton) are considerably broken (*md.*) and the oral face is evidently abraded, so that the punctate tritoral areas appear as if confined to the prominences. The presymphysial tooth (*ps.*) displays the outer convex face, coarsely striated longitudinally; and the irregularity of its inferior extremity suggests that that was its point of insertion. Only the anterior half of the oral face of the left palatine tooth ("mandibular tooth 1," Egerton) is exposed (*pl.*); but the whole of the attached surface of this tooth has been extricated from the matrix since its description by Egerton, and its precise outline can thus be ascertained. It exactly agrees with the corresponding tooth of the new specimen (No. P. 151) described below; but the only detail that can be observed upon the oral aspect is the presence of a broad depression extending obliquely backwards from the antero-external angle, and this was perhaps not covered by the tritoral area, which seems to extend over all other parts. The abruptly deflected anterior margin of the palatine tooth abuts against the small triangular vomerine tooth ("mandibular tooth 2," Egerton), in advance of which is the still smaller tooth ("mandibular tooth 3," Egerton), either as a separate element or merely an accidental dismemberment. The principal vomerine tooth (*v.*) has a gently tumid oral surface, with one large tritoral area and

five or six small, irregularly arranged, isolated patches; the oral aspect of the small anterior tooth (*x*.) is marked with large, parallel, transverse, mammillated ridges.

Enniskillen Coll.

P. 151. The complete dentition exposed from above, and partly from below, associated with three dermal plates; noticed by the present writer in the Ann. Mag. Nat. Hist. [6] vol. iv. (1889), p. 278. The specimen is shown, of the natural size, in Pl. II. fig. 2, and the parts are marked in accordance with the following description. The mandibular teeth (*md*.) are both shown from the inner and oral aspect, though partly obscured by the overlying palatines (*pl*.); and, so far as preserved, each seems to be precisely similar to the corresponding tooth in the group No. P. 477 (Pl. II. fig. 3). The presymphysial tooth, situated close to the position of the mandibular symphysis on the opposite side of the slab, is considerably crushed and broken, and thus appears relatively broader and more flattened than in the fossils described above. The palatine teeth (*pl*.) are large, thin, and plate-like, but unfortunately only exposed from the attached surface. Each of these teeth is elongated antero-posteriorly and must have originally possessed a nearly straight outer margin, somewhat thickened, and sharply deflected; the short anterior margin, forming an acute angle with the outer, is likewise deeply deflected and abuts against the vomerine tooth; but the inner and posterior margins are thin edges of nearly equal length, and there is no appearance of the close apposition of the right and left teeth in the median line. If the attached surface be approximately parallel to the oral surface in these teeth, there is a longitudinal median elevation, and this gradually disappears in the broad posterior extremity of the plate. The triangular vomerine tooth (*v*.) on each side is also seen to be thin and plate-like in form, its robust appearance, when viewed from the oral aspect, being due to the sharp deflection of all the margins. The pair of small anterior teeth (*x*) in advance of the vomerine is somewhat displaced; but the oral aspect of one (Pl. II. fig. 2 *a*) is well displayed, and exhibits the characteristic, mammillated, transverse ridges, consisting apparently of laminated dentine. *Purchased*, 1880.

Myriacanthus granulatus, Agassiz.

[Plate II. fig. 4; Plate III. figs. 3, 4.]

1837. *Myriacanthus granulatus*, L. Agassiz, Poiss. Foss. vol. iii. p. 40, pl. viii. *a*. fig. 16.
1837. *Leptacanthus tenuispinus*, L. Agassiz, *ibid.* p. 27, pl. i. figs. 12, 13. [Spine; British Museum.]
1871. *Ischyodus orthorhinus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xxvii. p. 275, pl. xiii. [Head, &c.; British Museum.]
1887. *Metopacanthus orthorhinus*, K. A. von Zittel, Handb. Palæont. vol. iii. p. 111.
1889. *Myriacanthus granulatus*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. iv. p. 279.

Type. Imperfect dorsal fin-spine; British Museum.

A species of comparatively small size, the dorsal spine attaining a maximum length of about 0·18. Dorsal spine much laterally compressed, with an acute anterior edge; lateral tubercles relatively small and closely arranged, absent upon a long extent from the much attenuated apex; anterior and posterior denticles long, comparatively slender, and closely arranged; a long series of the posterior denticles distally directed downwards, the others pointing upwards. Maximum thickness of presymphysial tooth about one third its breadth, and the tritor confined to a narrow median band, lenticular in section; outer face of the tooth strongly convex, with a sharply rounded, median, longitudinal elevation, the inner face equally concave.

This is the type species of the so-called *Metopacanthus*.

Form. & Loc. Lower Lias: Lyme Regis, Dorsetshire.

43050. Head and associated dorsal fin-spine in position, described and figured by Egerton, *loc. cit.*, as the type specimen of *Ischyodus orthorhinus*, and subsequently adopted as the type of *Metopacanthus* by Zittel, *loc. cit.* The rostral spine is shown to be covered superiorly with granulations, finer and more closely arranged than those of the sides of the dorsal spine. *Purchased*, 1871.

P. 4575. Remains of the head with dentition, and the basal half of the rostral spine; also a fragment of the dorsal spine, probably found associated. The jaws and a few dermal tubercles are shown, of the natural size, in Pl. II. fig. 4, and the parts are indicated by the lettering. A portion of the cartilage of the mandible is seen from the outer anterior aspect; and overlapping the oral margin is observed the pair of large mandibular teeth (*md.*). Immediately

above the right mandibular tooth rests the small incisor-like presymphysial tooth (*ps.*), which is shown in side view and transverse section, of three times the natural size, in figs. 4 *a*, 4 *b*. This tooth is much worn at its rounded functional extremity, and appears in transverse section (fig. 4 *b*) as if bent upon its mesial longitudinal line, which is in the form of a rounded ridge externally and a deep concavity internally; the tubular dentine does not cover the whole of the inner face, but forms a band occupying the greater part of the width of the concavity. The pair of anterior upper teeth (*v.*) is displayed from the oral aspect, each consisting of a broad triangular hinder portion, and a narrow quadrangular anterior portion, the latter crossed by few transverse ridges of laminated dentine. A fragment of one of the hinder upper teeth (*pl.*) is too imperfect for description. Some of the thorn-shaped dermal tubercles, upon expanded bases, evidently from the rostral spine, occur higher upon the slab (*t.*); and the basal half of the spine itself is shown from the dorsal aspect immediately adjoining. This spine expands at its base more gradually than that of *Squaloraja*, which it otherwise resembles in form; and there are traces of a very fine superficial granular ornament. *Enniskillen Coll.*

P. 1158. Fragmentary remains of head and dorsal fin-spine. Portions of the hinder pair of upper teeth are shown from the attached surface, and further posteriorly there is a triangular dermal plate, exposed from the outer aspect. This plate is raised to a somewhat excentric acuminate apex, and is covered with tuberculations arranged more or less in radiating lines; it is shown, of twice the natural size, in Pl. III. fig. 4. The dorsal spine is much crushed and abraded, but exhibits a few downwardly pointing posterior denticles distally, while a long series of upwardly directed denticles is preserved on the anterior border. *Egerton Coll.*

P. 3099. Left mandibular tooth, exposed from the oral aspect, and shown, of the natural size, in Pl. III. fig. 3. The symphysis (fig. 3, *a*) is narrow and shows the characteristic bevelling (*s*), much extended, probably for the accommodation of the median incisor-like tooth; while the oral surface is undulating, with one oblique median ridge and a somewhat raised post-oral border, neither parallel with the symphysial border, but much less nearly vertical. The

punctate dentine appears to be exposed only in a long narrow band on each of these two elevations.

Enniskillen Coll.

P. 3070. Imperfectly preserved distal portion of dorsal spine, the type specimen of *Myriacanthus granulatus*.

Enniskillen Coll.

P. 2848. Much broken distal extremity of dorsal spine in hard matrix, the type specimen of *Leptacanthus tenuispinus*.

Enniskillen Coll.

43065. Much abraded dorsal spine, wanting the basal portion.

Purchased, 1871.

P. 3072, P. 4454 b–e. Two imperfectly preserved dorsal spines, wanting the basal portion; also three fragments.

Enniskillen Coll.

P. 4876. Crushed spine, wanting anterior denticles.

Purchased, 1885.

41382. Distal portion of spine. *Purchased*, 1869.

The following specimen is also probably referable to *Myriacanthus*:—

P. 2850. Distal portion of dorsal spine, exhibiting a nearly smooth, slender, arcuated extremity, with four widely-spaced, large and downwardly curved posterior denticles, shown, of the natural size, in Pl. III. fig. 5; Lower Lias, Lyme Regis.

Enniskillen Coll.

Genus **CHIMÆROPSIS,** Zittel.

[Handb. Palæont. vol. iii. 1887, p. 113.]

Mandibular tooth with an undulating or gently curved oral surface and margin, with an extended, punctate, tritoral area. Presymphysial tooth vertically elongated, bilaterally symmetrical; the inner aspect flat or concave, the outer aspect convex. Palatine tooth thin, plate-like, triangular, and pointed behind. Vomerine tooth somewhat larger than the palatine, triangular, and pointed anteriorly; oral surface with an anterior and a posterior punctate tritoral area. Dorsal fin-spine elongated, more or less laterally compressed, and the sides ornamented with tuberculations; a series of large, thorn-shaped, spinous tubercles arranged along each side of the flattened posterior face, and a single series of similar denticles occupying at least part of the anterior border. Dermal plates tuberculated; trunk covered with small, conical, radiately grooved granules. (*Zittel.*)

Chimæropsis paradoxa, Zittel.

1843. "Knochen," H. von Meyer, in Münster's Beitr. Petrefakt. i. p. 96, pl. viii. fig. 1.

1887. *Chimæropsis paradoxa*, K. A. von Zittel, Handb. Palæont. vol. iii. p. 114, woodc. fig. 126.

1887. *Chimæropsis paradoxa*, J. Riess, Palæontogr. vol. xxxiv. p. 21, pl. ii. figs. 9–11, pl. iii. figs. 1–10.

Type. Imperfect skeleton; Palæontological Museum, Munich.

The type species, attaining a length of not less than one metre; dorsal spine in such a specimen 0·15 in length. Two closely apposed, angulated dermal plates on either side of the back of the head. Dorsal fin-spine rapidly tapering, gently arched, and all the anterior denticles pointing upwards. Mandibular tooth robust in appearance, with prominent beak and gently excavated, scarcely undulating oral margin; presymphysial tooth sharply rounded in front. Vomerine tooth about one and a half times as long as its maximum width behind; the maxillary tooth much narrower.

Form. & Loc. Lower Kimmeridgian (Lithographic Stone): Bavaria. Not represented in the Collection.

To *Chimæropsis* also must doubtless be assigned the first of the dorsal fin-spines described as follows:—

Myriacanthus franconicus, G. von Münster, Beitr. Petrefakt. iii. (1840), p. 127, pl. iii. fig. 8.—Upper Jurassic; Rabenstein, Bavaria.

Myriacanthus vesiculosus, G. von Münster, *ibid.* v. (1842), p. 111, pl. vi. fig. 3.—Corallian; Lindnerberg, Hanover. [? Fragment of *Asteracanthus*.]

A spine from the Lower Carboniferous of Russia, certainly not of the Myriacanthidæ, is named *Myriacanthus semigranulatus*, H. Romanowsky, Bull. Soc. Imp. Nat. Moscou, 1864, pt. ii. p. 167, pl. iv. fig. 34.

Family CHIMÆRIDÆ.

Body elongated; anterior dorsal fin above the pectorals, provided with a long, straight, robust spine. Teeth forming two pairs of robust dental plates in the upper jaw, both pairs thickened and closely apposed in the longitudinal mesial line of the mouth; lower dentition consisting of a single pair of large, beak-shaped plates, meeting at the symphysis; most of the plates with several tritoral areas. Dermal plates absent. Males with a prehensile spine upon the snout.

The genera and species of this family are distinguished by the characters of the dentition; and in the case of most of the extinct forms this is the only part of the skeleton available for study. A convenient nomenclature for the various parts of the teeth has thus been proposed by E. T. Newton[1]; and this will be adopted in the following pages, except that here the term "tritor" is substituted for "tooth."

Synopsis of Genera.

A. Outer tritors of mandibular teeth two (anterior and posterior).
  Mandibular tooth with narrow symphysial surface, and external thickening along the oral border. Palatine tooth with deeply cleft posterior border, and the tritors in an outer and an inner longitudinal series ..... *Ganodus* (p. 55).
  Mandibular tooth with narrow symphysial surface, and external thickening along the oral border. Palatine tooth with four tritors, two being inner, one median, and one outer; no posterior excavation ..... *Ischyodus* (p. 59).
  Mandibular tooth with broad symphysia surface, and no external thickening along the oral border. Palatine tooth with three tritors, two being inner and one outer; no posterior excavation .. *Edaphodon* (p. 73).
B. Outer tritors of mandibular teeth absent.
  Mandibular tooth with narrow symphysial surface, and external thickening along the oral border. Palatine tooth with single large tritor divided into two processes anteriorly ..... *Callorhynchus* (p. 87).
C. Mandibular teeth thin, with the outer tritors small and numerous, and symphysis narrow.
  Mandibular tooth with two rows of dot-like beak-tritors and similar outer tritors; median tritor absent. [Palatine tooth unknown.] ..... *Elasmodectes* (p. 88).
  Mandibular tooth with large beak-tritor, this and the outer tritors being laminated; median tritor present. Palatine tooth with four tritors, two being inner, one median, and one outer, the three first with tendency to fusion .. *Elasmodus* (p. 88).

[1] Chimæroid Fishes, Brit. Cretaceous Rocks (Mem. Geol. Surv. 1878), p. 4.

Mandibular tooth with two or more beak-tritors and numerous dot-like outer tritors; median tritor present. Palatine tooth with variable inner tritors and a series of small outer tritors .... *Chimæra* (p. 91).

The characters of the oral aspect of the palatine and mandibular teeth in these genera are indicated in a diagrammatic manner in the figures given below.

Fig. 6.

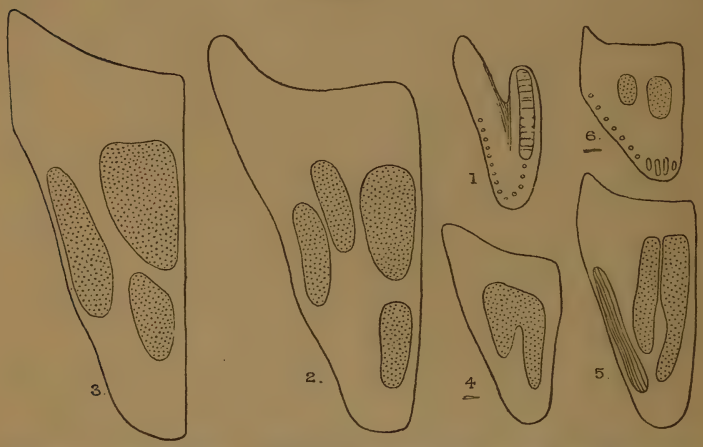


Diagram of the oral aspect of the left palatine tooth in the principal genera of Chimæridæ, showing the arrangement of the tritors.—1. *Ganodus*. 2. *Ischyodus*. 3. *Edaphodon*. 4. *Callorhynchus*. 5. *Elasmodus*. 6. *Chimæra*.

Fig. 7.

Diagram of the inner aspect of the left mandibular tooth in the principal genera of Chimæridæ, showing the arrangement of the tritors and the extent of the symphysis. Nos. as in fig. 6, with addition of 7. *Elasmodectes*.

Genus **GANODUS**, Agassiz (emend. A. S. W.)[1].

[Poiss. Foss. vol. iii. 1843, p. 339.]

Syn. *Leptacanthus*, L. Agassiz, *ibid.* 1837, p. 27 (in part).
Psittacodon, L. Agassiz, *ibid.* 1843, p. 340 (in part).

An imperfectly known genus comprising species only of small size. Mandibular tooth as in *Ischyodus*. Palatine tooth robust, with a well-defined hard layer upon the outer aspect immediately above the oral margin; posterior border deeply notched, the sinus continued forwards as a median longitudinal groove, gradually becoming shallower, and separating the inner from the outer tritors; inner tritors forming a narrow longitudinal band, more or less discontinuous; outer tritors similar, but smaller, and the two series usually connected anteriorly.

As remarked by Agassiz, the median and outer tritors of the mandibular teeth are remotely placed and closely approximated; they are, however, never fused together, and the characters of the palatine teeth only are sufficient to justify the separation of the genus from *Ischyodus*.

Ganodus oweni, Agassiz.

[Plate I. fig. 9.]

1843. *Chimæra* (*Ganodus*) *owenii*, L. Agassiz, Poiss. Foss. vol. iii. p. 347, pl. xl. figs. 6, 7.
1843. *Ischyodus oweni*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156.
1847. *Ganodus oweni*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iii. p. 352.
1890. *Ganodus oweni*, A. S. Woodward, Proc. Geol. Assoc. vol. xi. p. 303.
(?) 1890. *Ganodus* sp., A. S. Woodward, *ibid.* pl. iii. fig. 4.

Type. Theoretically associated mandibular and palatine teeth; British Museum.

Mandibular tooth with a gently wavy oral margin and a relatively long post-oral margin much less vertically inclined than the symphysial margin; median tritor immediately behind and below the anterior outer tritor, somewhat narrower than the space between it and the symphysial margin, and notched antero-superiorly. (?) *Palatine tooth* with the inner tritoral series almost continuous in its posterior half, the outer series consisting of minute, well-separated tritors.

[1] Sir Philip Egerton states (Quart. Journ. Geol. Soc. vol. iii. 1847, p. 350) that he defined this genus in 1843. There does not appear, however, to be any published record.

This may be regarded as the type species of the genus as here defined.

Form. & Loc. Bathonian (Stonesfield Slate): Stonesfield, Oxfordshire.

P. 486. Right mandibular tooth, inner aspect, to be regarded as the type specimen; figured by Agassiz, *tom. cit.* pl. xl. fig. 7. *Egerton Coll.*

P. 3100, P. 3105 a. Two left mandibular teeth, exhibiting the inner aspect, labelled by Agassiz. *Enniskillen Coll.*

36584. Broken left mandibular tooth, inner aspect. *Purchased*, 1862.

P. 5108. Left mandibular tooth, outer aspect. *Presented by J. E. Lee, Esq.*, 1885.

P. 485. Right palatine tooth, exhibiting only the superior aspect, figured by Agassiz, *tom. cit.* pl. xl. fig. 6. *Egerton Coll.*

P. 1133. Left palatine tooth, oral aspect, figured in Proc. Geol. Assoc. vol. xi. pl. iii. fig. 4. *Egerton Coll.*

P. 3100 b, c. Two similar left palatine teeth, one being shown, of the natural size, in Pl. I. fig. 9. The oral aspect not being exposed in no. P. 485, these two specimens, with no. P. 1133, cannot be precisely compared, but their identity is probable and one is labelled "*Chimæra owenii*, Buckl.," in Agassiz's handwriting. *Enniskillen Coll.*

P. 3100 a. Right vomerine tooth, resembling that of *Ischyodus* in form, and labelled by Agassiz as pertaining to this species. *Enniskillen Coll.*

Two "species" of *Ganodus*—*G. falcatus*, Egerton[1], and *G. psittacinus*, Egerton[2]—have also been founded upon mandibular teeth exhibiting the external aspect, and are not yet distinguishable with certainty from *G. oweni*. Both type specimens were obtained from the Stonesfield Slate, and are contained in the Egerton Collection. Of the left mandibular tooth described and figured as *G. falcatus* (**P. 482**), it is not improbable that the form of the oral margin and the prominence of the beak are due to accident; and, though

[1] Quart. Journ. Geol. Soc. vol. iii. (1847), p. 352. *Chimæra falcata*, Proc. Geol. Soc. vol. iv. (1843), p. 154. *Ischyodus falcatus*, Sir P. Egerton, *ibid.* 1843, p. 156. *Chimæra* (*Psittacodon*) *falcata*, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 349, pl. xl. *c.* fig. 13.

[2] Quart. Journ. Geol. Soc. vol. iii. (1847), p. 352. *Chimæra psittacina*, Proc. Geol. Soc. vol. iv. (1843), p. 153. *Ischyodus psittacinus*, Sir P. Egerton, *ibid.* 1843, p. 156. *Chimæra* (*Psittacodon*) *psittacina*, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 350, pl. xl. *c.* fig. 12.

differing in being of much smaller size, the right mandibular tooth described and figured as *G. psittacinus* (**P. 484**) displays a contour very suggestive of that of *G. oweni*.

Closely related either to *G. oweni* or to *G. dentatus* is the following small left mandibular tooth, which exhibits only the outer aspect:—

P. 481. Type specimen of *Chimæra neglecta*, Egerton, Proc. Geol. Soc. vol. iv. (1843), p. 153, subsequently named *Ischyodus neglectus*, Egerton, *ibid.* p. 156, and *Ganodus neglectus*, Egerton, Quart. Journ. Geol. Soc. vol. iii. (1847), p. 352, and described and figured by Agassiz, Poiss. Foss. vol. iii. (1843), p. 347, pl. xl. *c.* fig. 11, under the name of *Chimæra* (*Ganodus*) *neglecta*; Stonesfield Slate, Stonesfield.

Egerton Coll.

Ganodus dentatus, Egerton.

[Plate I. fig. 10.]

1847. *Ganodus dentatus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iii. p. 353.

Type. Left mandibular tooth; British Museum.

Mandibular tooth with a prominently sinuous oral margin and a relatively long post-oral margin, less vertically inclined than the symphysial margin; median tritor narrow, immediately behind and below the anterior outer tritor; both outer tritors exposed as a vertical series of tubercles.

Form. & Loc. Bathonian (Stonesfield Slate): Stonesfield.

P. 614. Type specimen, shown, of twice the natural size, in Pl. I. fig. 10. *Egerton Coll.*

Ganodus rugulosus, Egerton.

[Plate I. fig. 11.]

1843. *Chimæra rugulosa*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 154.
1843. *Ischyodus rugulosus*, Sir P. Egerton, *ibid.* p. 156.
1843. *Chimæra* (*Ganodus*) *rugulosa*, L. Agassiz, Poiss. Foss. vol. iii. p. 347.
1847. *Ganodus rugulosus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iii. p. 352.

Type. Imperfect right mandibular tooth; British Museum.

Mandibular tooth with a very gently sinuous oral margin and a relatively long post-oral margin, much less vertically inclined than the symphysial margin; median tritor small and narrow, situated well behind and below the anterior outer tritor; both outer tritors very small.

Form. & Loc. Bathonian (Stonesfield Slate): Stonesfield.

P. 600. Type specimen, almost detached from matrix and much abraded externally. *Egerton Coll.*

P. 5152. Right mandibular tooth exhibiting relatively larger tritors, but probably of this species, shown, of the natural size, in Pl. I. figs. 11 *a*, *b*. *Egerton Coll.*

P. 3105. Imperfect left mandibular tooth, outer aspect. *Enniskillen Coll.*

A supposed distinct species is founded upon a right mandibular tooth exhibiting only the outer aspect; but it is not capable of definition and precise separation from *G. rugulosus*. The original specimen was described as *Chimæra curvidens*, Egerton, Proc. Geol. Soc. vol. iv. (1843), p. 154, and subsequently named *Ischyodus curvidens*, Egerton, *ibid.* p. 156, and *Ganodus curvidens*, Egerton, Quart. Journ. Geol. Soc. vol. iii. (1847), p. 352; it is placed first in the following series of teeth from the Stonesfield Slate, which represent the "species" in the collection :—

P. 599. Type specimen, shown, of natural size, in Pl. I. fig. 12. *Egerton Coll.*

P. 3104. More imperfect left mandibular tooth of similar form. *Enniskillen Coll.*

28595. Small right mandibular tooth; Eyeford, Gloucestershire. *Purchased*, 1853.

Ganodus sp.

[Plate I. fig. 13.]

A single example of a palatine tooth from the Stonesfield Slate (**P. 3107.** *Enniskillen Coll.*) indicates an unusually large species of *Ganodus*. The specimen is of the right side and is shown, of the natural size, from the oral aspect, in Pl. I. fig. 13; the inner tritors are few, large, and well-separated, and the outer tritors have only three minute representatives. It is possible that the fossil pertains to the same species as the imperfect right mandibular tooth described as *Chimæra bucklandi*, Egerton, Proc. Geol. Soc. vol. iv. (1843), p. 153, *Ischyodus bucklandi*, Egerton, *ibid.* p. 156, and subsequently described and figured by Agassiz, Poiss. Foss. vol. iii. (1843), p. 343, pl. xl. *c*. fig. 19, under the name of *Chimæra* (*Ischyodon*) *bucklandi*, afterwards assigned to *Ganodus* by Egerton, Quart. Journ. Geol. Soc. vol. iii. (1847), p. 352. This specimen, however (**P. 478.** *Egerton Coll.*), is too imperfect both for generic and specific determination.

To *Ganodus*, also, must probably be assigned the following small dorsal fin-spines from the Stonesfield Slate, all obtained from Stonesfield, unless otherwise stated :—

P. 2846–7. One of the type specimens of *Leptacanthus semistriatus*, Agassiz, figured in the Poiss. Foss. vol. iii. pl. vii. fig. 6; also two larger portions of similar spines.
Enniskillen Coll.

47975–77. Portions of three similar spines.
Presented by the Hon. Robert Marsham, 1877.

P. 251. Abraded spine of the same "species."
Presented by J. Wood-Mason, Esq. 1880.

P. 2213. Two nearly complete similar spines. *Egerton Coll.*

P. 4173. Impression of a similar spine labelled by Agassiz thus:—"Peut-être le rayon du *Psammodus magnus*; décrit sous le nom de *Leptacanthus semistriatus*." *Enniskillen Coll.*

P. 3108. Type specimen of *Leptacanthus serratus*, Agassiz, described and figured in the Poiss. Foss. vol. iii. (1837), p. 29, pl. vii. fig. 1. *Enniskillen Coll.*

28596. Portion of distal half of a similar spine; Eyeford, near Naunton, Gloucestershire. *Purchased*, 1853.

P. 6222. Crushed portion of a similar spine.

Genus **ISCHYODUS**, Egerton.

[Proc. Geol. Soc. vol. iv. 1843, p. 155.]

Syn. *Leptacanthus*, L. Agassiz, Poiss. Foss. vol. iii. 1837, p. 27 (in part).
Auluxacanthus, H. E. Sauvage, Catal. Poiss. Form. Second. Boulonnais (Mém. Soc. Acad. Boulogne, vol. ii.), 1867, p. 63.
Chimæracanthus, F. A. Quenstedt, Der Jura, 1858, p. 347.

Mandibular tooth more or less massive, with a well-defined hard layer upon the outer aspect immediately below the oral margin; one anterior tritor usually present, sometimes several; one median tritor, and two or more external tritors. Palatine tooth very robust, with a well-defined hard layer upon the outer aspect immediately above the oral margin; four tritors present, two being inner, one median, and one outer. Vomerine tooth more or less quadrate in side view, with tritors upon the oral margin; post-oral region not laterally expanded, and usually with a definite hard thickening. Dorsal fin-spine laterally compressed, smooth or longitudinally striated, with a double series of posterior denticles. Head-spine of male short, arched, with a terminal cluster of denticles.

Ischyodus colei (Agassiz).

[Plate I. fig. 14.]

1843. *Chimæra* (*Ganodus*) *colei*, L. Agassiz (*ex* Buckland, MS.), Poiss. Foss. vol. iii. p. 346, pl. xl. figs. 8–10.
1843. *Ischyodus colii*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156.
1847. *Ganodus colei*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iii. p. 352.
1890. *Ischyodus colei*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 105.

Type. Theoretically associated mandibular and palatine teeth; British Museum.

(?) *Mandibular tooth* with a gently wavy oral margin and a relatively long post-oral margin nearly parallel to the symphysial. *Palatine tooth* with all the tritors of small size, the posterior inner being larger than the other three taken together, and the median tritor the smallest of all.

The type specimen of the mandibular tooth not being sufficiently perfect for definition, the palatine tooth may be regarded as the type of the species.

Form. & Loc. Bathonian (Stonesfield Slate): Oxfordshire.

P. 1134 a. Right mandibular tooth, outer aspect, much abraded, figured by Agassiz, *tom. cit.* pl. xl. fig. 8; Stonesfield.
Egerton Coll.

P. 480. Left palatine tooth, oral aspect, figured by Agassiz, *ibid.* fig. 9, and re-figured in Pl. I. fig. 14; Stonesfield.
Egerton Coll.

P. 1134. Right palatine tooth, superior aspect; Stonesfield.
Egerton Coll.

P. 3101–2. Four palatine teeth, one showing the superior aspect, the others the oral aspect; Stonesfield.
Enniskillen Coll.

Ischyodus emarginatus, Egerton.

1843. *Chimæra* (*Ischyodus*) *emarginata*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. pp. 154, 156.
1843. *Chimæra* (*Ischyodon*) *tessoni*, L. Agassiz, Poiss. Foss. vol. iii. p. 342, pl. xl. fig. 19. [Mandibular tooth; British Museum.]

Type. Left mandibular tooth; British Museum.

This species is only provisionally retained distinct from *I. egertoni*, the difference of proportions not sufficing to justify its separation.

The posterior outer tritor appears to be much more feebly developed than in the last-named species, but otherwise the arrangement is similar. Many Kimmeridgian fossils, presumably referable to *I. egertoni*, exhibit as much antero-posterior elongation as those placed here; and short and long varieties of the mandibular teeth have also been observed in other species, e. g. *I. thurmanni* (*I. brevirostris*, Newton).

Form. & Loc. Bathonian: Oxfordshire, Gloucestershire, and Normandy.

P. 3106. Left mandibular tooth, described as the type specimen by Egerton, *loc. cit.*; Stonesfield Slate, Stonesfield, Oxfordshire. *Enniskillen Coll.*

P. 5150. Imperfect right mandibular tooth, outer aspect; Stonesfield. *Egerton Coll.*

28592. Nearly similar specimen; Eyeford, Gloucestershire. *Purchased*, 1853.

32545. Right mandibular tooth, forming the type specimen of *I. tessoni*, Agassiz, *tom. cit.*; Caen, Normandy. *Tesson Coll.*

41307. Two imperfect pairs of mandibular teeth; Caen. *Purchased*, 1869.

44830. Upper portion of small right mandibular tooth; Caen. *Presented by Benjamin Bright, Esq.*, 1873.

Ischyodus egertoni (Buckland).

1835. *Chimæra egertonii*, W. Buckland, Proc. Geol Soc. vol. ii. p. 206.
1836. *Chimæra egertonii*, W. Buckland, Phil. Mag. [3] vol. viii. p. 5.
1843. *Ischyodus egertoni*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156.
1843. *Chimæra* (*Ischyodon*) *egertoni*, L. Agassiz, Poiss. Foss. vol. iii. p. 340, pl. xl. *c.* figs. 1–10.
1871. *Ischyodus egertoni*, J. Phillips, Geol. Oxford, p. 306, pl. xii. fig. 24.

Type. Mandibular tooth, and the theoretically associated palatine and vomerine teeth; Oxford Museum.

Mandibular tooth with a deeply sinuous oral margin, acute eminences corresponding to the beak and outer tritors, and the post-oral margin nearly parallel to the symphysial; beak-tritor narrow and elongated antero-posteriorly; outer tritors well developed; median tritor broad, and occupying the greater portion of the

oral surface below and behind the apex of the anterior outer tritor. (?) *Palatine tooth* with the posterior inner tritor of large size, and the median tritor extending further forwards than this; outer tritor much elongated and extending far forwards. (?) *Vomerine tooth* of the typical quadrate outline, with about six uniform tritors upon the oral margin.

Form. & Loc. Oxford Clay: Oxfordshire and Northamptonshire. Kimmeridge Clay: Oxfordshire and Dorsetshire.

P. 476. Left mandibular tooth, right palatine, and right and left vomerine teeth, described and figured by Agassiz, *tom. cit.*; Kimmeridge Clay, Shotover, near Oxford. *Egerton Coll.*

41173, 41226, 41395, 41863–4, 41961. Three mandibular teeth, and two pairs of small mandibular teeth; Kimmeridge Clay, Weymouth. *Purchased*, 1868–70.

P. 1159 a. Small left mandibular tooth; Kimmeridge. *Egerton Coll.*

P. 3094. Three mandibular teeth; Weymouth. *Enniskillen Coll.*

41174, 41225, 41397. Left palatine tooth, and two imperfect examples of the right side; Weymouth. *Purchased*, 1868–69.

P. 3093 a. Imperfect left palatine tooth; Weymouth. *Enniskillen Coll.*

41396, 41962. Imperfect right vomerine tooth, and a pair of larger, but similar teeth; Weymouth. *Purchased*, 1869–70.

41865. Mandibular tooth of young; Weymouth. *Purchased*, 1870.

Ischyodus dufrenoyi, Egerton.

1843. *Chimæra dufrenoyi*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 155.

1843. *Ischyodus duvernoyi*, Sir P. Egerton, *ibid.* p. 156 (*errore*).

1867. *Ischyodus dufrenoyi*, H. E. Sauvage, Catal. Poiss. Form. Second. Boulonnais (Mém. Soc. Acad. Boulogne, vol. ii.), p. 73, pl. iv. fig. 12.

Type. Left mandibular tooth.

Mandibular tooth much compressed, with a deeply sinuous oral margin, a prominent symphysial beak, and the post-oral margin much more inclined backwards than the symphysial margin, which is gently arched; beak-tritor very small; outer tritors well developed; median tritor occupying the greater portion of the oral

surface below and behind the apex of the anterior outer tritor. (?) *Palatine tooth* with the posterior inner tritor of large size, and the median tritor not extending further forwards than this; outer tritor much elongated and extending far forwards.

Form. & Loc. Kimmeridge Clay: Boulogne, N. France.

32416. Left mandibular tooth, probably referred to by Sauvage, *op. cit.* p. 74. *Purchased*, 1857.

32767. More imperfect large specimen, of the right side. *Purchased*, 1857.

32768. Right palatine tooth. *Purchased*, 1857.

Ischyodus beaumonti, Egerton.

1843. *Chimæra* (*Ischyodus*) *beaumonti*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. pp. 155, 156.
1843. *Chimæra* (*Ischyodon*) *beaumontii*, L. Agassiz, Poiss. Foss. vol. iii. p. 346.
1847. *Ischyodus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iii. p. 351, pl. xiii. fig. 1.
1866. *Ischyodus beaumontii*, E. T. Hamy, Bull. Soc. Géol. France, [2] vol. xxiii. p. 655, woodc. fig. 1.
1867. *Ischyodus beaumontii*, H. E. Sauvage, Catal. Poiss. Form. Second. Boulonnais (Mém. Soc. Acad. Boulogne, vol. ii.), p. 83, pl. iv. figs. 4, 5.
(?) 1867. *Ischyodus rigauxi*, H. E. Sauvage, *ibid.* p. 76, pl. iv. figs. 14, 15. [Mandibular tooth; Boulogne Museum.]
1890. *Ischyodus beaumonti*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 105.

Type. Right palatine tooth.

(?) *Mandibular tooth* with a very gently wavy oral margin, a short post-oral margin nearly parallel to the symphysial, and the beak more or less produced and acute; beak-tritor small, elongated antero-posteriorly, with one or two minute tritors immediately within; both outer tritors present, though small; median tritor very large and broad, occupying the greater portion of the oral aspect and nearer the post-oral than the symphysial margin. *Palatine tooth* with the posterior inner tritor of large size, and the median tritor not extending so far forwards as this; outer tritor somewhat elongated. (?) *Vomerine tooth* relatively deep, with a series of small tritors.

The mandibular tooth assigned to this species is described by Sauvage under the name of *I. rigauxi*.

Form. & Loc. Kimmeridge Clay: N. France and Dorsetshire.

43023, 43283. Right and left palatine teeth, probably of a single individual; Weymouth. *Purchased*, 1871.

41224, 41959, 42362. One imperfect and two complete smaller palatine teeth; Weymouth. *Purchased*, 1868–70.

P. 3093. A still smaller left palatine tooth, and two very small examples; Weymouth. *Enniskillen Coll.*

41396, 43557. Two right vomerine teeth: Weymouth. *Purchased*, 1869, 1872.

P. 1159. Imperfect left palatine and two right mandibular teeth; Kimmeridge. *Egerton Coll.*

32417. Left mandibular tooth, mentioned under the name of *I. rigauxi* by H. E. Sauvage, *op. cit.* p. 79; Boulogne. *Purchased*, 1857.

41960, 42363, 43024, 43282. Three pairs of mandibular teeth; Weymouth. *Purchased*, 1868–72.

41172, 41394, 43556. Three mandibular teeth, one being of the right, and two of the left side; Weymouth. *Purchased*, 1868–72.

P. 6163. Pair of mandibular teeth, the left figured in Damon's Geol. Weymouth, Suppl. pl. xii. fig. 4; Weymouth. *Purchased*, 1890.

Ischyodus townsendi (Buckland).

1835. *Chimæra townsendii*, W. Buckland, Proc. Geol. Soc. vol. ii. p. 206.
1836. *Chimæra townsendii*, W. Buckland, Phil. Mag. [3] vol. viii. p. 5.
1843. *Ischyodus townshendi*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156.
1843. *Chimæra* (*Ischyodon*) *townsendii*, L. Agassiz, Poiss. Foss. vol. iii. p. 343, pl. xl. figs. 20-22, pl. xl. *c*. figs. 17, 18.
1878. *Ischyodus townsendii*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Monogr. iv.), p. 33, pl. xi.
1881. *Ischyodus townsendii*, E. T. Newton, Proc. Geol. Assoc. vol. vii. p. 116, woodc.

Type. Mandibular and theoretically associated vomerine teeth; British Museum.

The type species of very large size, the measurement from the symphysial border to the extremity of the post-oral margin of the mandibular tooth being sometimes 0·14. *Mandibular tooth* with

a gently wavy oral margin, a short post-oral margin nearly parallel to the symphysial, and the beak prominent; beak-tritor divided into a series of small separate tritors; anterior outer tritor relatively small, divided into two or more portions; posterior tritor absent; median tritor large, occupying the middle of the tooth, immediately below and in advance of the anterior outer tritor. *Palatine tooth* with the posterior inner and median tritors very large, and the outer tritor divided into a short series. *Vomerine tooth* with a series of five or six tritors, the inner being larger than the others.

Form. & Loc. Portlandian: Oxfordshire, Wiltshire, and Dorsetshire. (Derived fossils in Neocomian Bone-beds of Bedfordshire and Cambridgeshire.)

P. 474. Left mandibular tooth figured by Agassiz, *tom. cit.* pl. xl. fig. 20, to be regarded as the type specimen; Great Milton, near Oxford. *Egerton Coll.*

P. 3095, P. 3095 a. More imperfect right mandibular tooth and fragment; Great Milton. *Enniskillen Coll.*

P. 1136, P. 4450. Fragments of mandibular teeth; Great Haseley, near Oxford. *Egerton & Enniskillen Colls.*

46400. Imperfect right mandibular tooth, noticed by E. T. Newton, *op. cit.* p. 36; Swindon, Wiltshire. *Cunnington Coll.*

P. 6033. Right mandibular tooth; Portland.
Presented by George Clifton, Esq., 1889.

40476. Much abraded right mandibular tooth, figured by E. T. Newton, *op. cit.* pl. xi. fig. 2; Neocomian Bone-bed, Potton, Bedfordshire. *Purchased*, 1867.

P. 3096. Fragments of mandibular teeth; Potton.
Enniskillen Coll.

P. 6032. Associated fragments of teeth; Portland.
Presented by George Clifton, Esq., 1889.

P. 409. Left palatine tooth; Portland.
Presented by William Davies, Esq., 1881.

P. 1135. Right vomerine tooth, noticed by Agassiz, *tom. cit.* p. 344, and by E. T. Newton, *op. cit.* p. 36; Garsington, near Oxford. *Egerton Coll.*

P. 3096 a. Left vomerine tooth; Potton. *Enniskillen Coll.*

Ischyodus quenstedti, Wagner.

1857. *Chimæra* (*Ischyodon*) *quenstedti*, A. Wagner, Gelehr. Anz. k. bay. Akad. vol. xliv. p. 288.

1862. *Chimæra* (*Ischyodon*) *quenstedti*, A. Wagner, Abh. math.-phys. Cl. k. bay. Akad. Wiss. vol. ix. p. 286, pl. i. fig. 1.

1887. *Ischyodus quenstedti*, J. Riess, Palæontogr. vol. xxxiv. p. 6, pl. i. figs. 1–5, pl. ii. figs. 1–7.

Type. Greater portion of skeleton; Palæontological Museum, Munich.

A species almost equalling *I. townsendi* in size, the trunk attaining a total length of 1·5. *Mandibular tooth* with a gently wavy oral margin, a short post-oral margin almost parallel to the symphysial, and the beak short; anterior and posterior outer tritors small, undivided; median tritor large, extending backwards from a point in advance of the anterior outer tritor, and only separated from the posterior outer tritor by a very narrow space. *Palatine tooth* with each of the tritors well developed, except the median, which is very small; none subdivided.

Form. & Loc. Lower Kimmeridgian (Lithographic Stone): Bavaria.

38005. Plaster cast of dorsal fin-spine of the type specimen, described and figured by Wagner, Abh. math.-phys. Cl. k. bay. Akad. Wiss. vol. ix. pl. i. fig. 1; Eichstädt.

Purchased, 1864.

37021. Remains of the head and anterior portion of the trunk of a male individual of moderate size, preserved in counterpart slabs, and displaying the dentition, frontal spine, and dorsal fin-spine; Solenhofen. The teeth are considerably crushed and not one satisfactorily exhibits the oral aspect. The frontal spine is also crushed, but evidently large, broad, widening proximally, and provided in the distal half with a tuft of recurved, subulate denticles. The dorsal spine resembles that already figured by Wagner.

Häberlein Coll.

Ischyodus avitus (Meyer).

1860. *Chimæra* (*Ganodus*) *prisca*, H. von Meyer, Neues Jahrb. p. 212 (name subsequently withdrawn).

1862. *Chimæra* (*Ganodus*) *avita*, H. von Meyer, Palæontogr. vol. x. p. 87, pl. xii.

1887. *Ischyodus avita*, J. Riess, Palæontogr. vol. xxxiv. p. 14, pl. i. figs. 6, 7, pl. ii. fig. 8.

Type. Skeleton; Palæontological Museum, Munich.

A species known only by a small skeleton, which exhibits the outer lateral aspect of the dentition. Head occupying somewhat less than one-quarter of the total length; tail rapidly tapering. Space between pectoral and pelvic fins about equal to the distance of the former from the end of the snout. Dorsal fin-spine comparatively short and robust, its length about equal to the depth of the trunk at its point of insertion. Oral margin of mandibular tooth regularly and deeply sinuous; post-oral margin nearly parallel with the symphysial margin.

Form. & Loc. Lower Kimmeridgian (Lithographic Stone): Bavaria.

Not represented in the Collection.

Ischyodus planus, Newton.

1878. *Ischyodus planus,* E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv.), p. 37, pl. xii. figs. 1, 2.

Type. Mandibular tooth; collection of Thomas Jesson, Esq.

A species of large size, known only by the mandibular teeth. *Mandibular tooth* with a gently wavy oral margin (and beak probably short); beak-tritor single, laminated; outer tritors rudimentary; median tritor large, occupying nearly half of the oral surface, and posteriorly situated.

Form. & Loc. Cambridge Greensand: Cambridge. (?) Upper Chalk: Norfolk.

48945. Fragment of mandibular tooth, doubtfully assigned to this species by Newton, *op. cit.* p. 38; U. Chalk, Norwich.
Bayfield Coll.

Ischyodus thurmanni, Pictet & Campiche.

1843. *Ischyodus brevirostris,* Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156 (name only).

1843. *Chimæra* (*Ischyodon*) *brevirostris,* L. Agassiz, Poiss. Foss. vol. iii. p. 344 (name only).

1843. *Chimæra* (*Ischyodon*) *agassizii,* L. Agassiz (*errore*), *ibid.* pl. xl. *c.* figs. 14, 15.

1858. *Ischyodon thurmanni,* Pictet & Campiche, Foss. Terr. Crétacé St.-Croix (Pal. Suisse), p. 76, pl. ix. fig. 8.

1862. *Ischyodus agassizii,* W. H. Bensted (*errore*), Geologist, vol. v. p. 378.

1867. *Ischyodus bouchardi,* H. E. Sauvage, Catal. Poiss. Second. Boulonnais (Mém. Soc. Acad. Boulogne-sur-Mer. vol. ii.), p. 81, pl. iv. fig. 6. [Mandibular tooth.]

1876. *Ischyodus brevirostris*, E. T. Newton, Quart. Journ. Geol. Soc. vol. xxxii. p. 326, pl. xxi. fig. 5. [Teeth; British Museum.]

1878. *Ischyodus brevirostris*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv.), p. 27, pl. ix.

1888. *Ischyodus brevirostris*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. iv. p. 42, pl. vii. figs. 10–13.

Type. Imperfect palatine tooth.

Mandibular tooth notably robust, with a deeply sinuous oral margin, acute eminences corresponding to the outer tritors, and the beak prominent; post-oral margin much less vertically inclined than the symphysial margin; beak-tritor minute; outer tritors well-developed; median tritor narrow or of moderate width, occupying the greater portion of the oral surface immediately behind the anterior outer tritor. *Palatine tooth* with the posterior inner tritor of moderate or large size, and the median tritor not extending so far forwards as this; outer tritor much elongated. *Vomerine tooth* much deeper at the symphysis than externally.

Form. & Loc. Lower Greensand: Kent. Albian: Kent, England, and St.-Croix, Switzerland. Cenomanian and Turonian: Cambridgeshire and Kent. Greensand: Amuri Bluff, New Zealand (*Newton* and *Davis*).

(i.) *Lower Greensand, Maidstone.*

41682 a. Elongated right mandibular tooth, described and figured by E. T. Newton, *op. cit.* p. 31, pl. ix. fig. 10. *Toulmin-Smith Coll.*

P. 1155. Fragmentary left mandibular tooth, noticed by E. T. Newton, *op. cit.* p. 28. *Egerton Coll.*

P. 3091–2. Two imperfect mandibular teeth. *Enniskillen Coll.*

P. 475. Right palatine tooth, assigned to "*Chimæra* (*Ischyodon*) *agassizii*" by Agassiz, *tom. cit.* pl. xl. *c.* figs. 14, 15. *Egerton Coll.*

(ii.) *Gault, Folkestone.*

47173 a, 47177. Right mandibular tooth and a pair, the former and one of the latter being figured by E. T. Newton, *op. cit.* pl. ix. figs. 3–5. *Gardner Coll.*

47175, 47178, P. 27, P. 28. Four pairs of mandibular teeth. *Gardner Coll.*

47173–74, P. 29. Six mandibular teeth, three of each side. *Gardner Coll.*

P. 32, P. 33. Two very small mandibular teeth. *Gardner Coll.*

35869, 43076, 43083. Three mandibular teeth.
Purchased, 1861, 1871.

P. 3086. Portion of right mandibular tooth labelled by Agassiz "*Chimæra brevirostris*, Agass.," and intended to become the type specimen of the species thus named in MS. The fragment is figured by E. T. Newton, *op. cit.* pl. ix. figs. 1, 2. *Enniskillen Coll.*

P. 26. Left mandibular tooth, associated with the left palatine.
Gardner Coll.

47176. Associated right and left palatine, and right vomerine tooth, figured by E. T. Newton, *op. cit.* pl. ix. figs. 13, 14, 20.
Gardner Coll.

47179, 46843. Two left palatine teeth, the oral aspect of the first being figured by E. T. Newton, *op. cit.* pl. ix. fig. 15.
Gardner Coll.

36910. Right palatine tooth. *Purchased*, 1863.

(iii.) *Cambridge Greensand, Cambridge.*

35147–50, 35160, 35373. Eight mandibular teeth, more or less fragmentary. *Purchased*, 1859.

P. 1140. Two left mandibular teeth. *Egerton Coll.*

35140. Right palatine tooth. *Purchased*, 1859.

P. 1139. Three palatine teeth. *Egerton Coll.*

P. 3087. Three palatine teeth, one being very imperfect.
Enniskillen Coll.

39101. Right vomerine tooth, figured by E. T. Newton, *op. cit.* pl. ix. fig. 21. *Bowerbank Coll.*

35152–3, 35450. Three vomerine teeth. *Purchased*, 1859.

P. 1141. Right vomerine tooth. *Egerton Coll.*

(iv.) *Lower Chalk, Burham, Kent.*

49019. Right palatine tooth, probably of this species.
Mrs. Smith's Coll.

(v.) *Greensand, Amuri Bluff, New Zealand.*

P. 2302. Right mandibular tooth, assigned to this species by E. T. Newton, Quart. Journ. Geol. Soc. vol. xxxii. p. 326, pl. xxi. fig. 5. *By exchange*, 1876.

Ischyodus latus, Newton.

1878. *Ischyodus latus*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv.), p. 32, pl. x. figs. 1–3 (? figs. 4–12).

Type. Mandibular tooth; Museum of Practical Geology.

Mandibular tooth closely resembling that of *I. thurmanni*, but the median tritor very broad and extending forwards to the symphysis. Supposed *palatine tooth* with very broad tritors covering nearly the whole of the oral surface, the outer tritor being narrow, and the median extending further forwards than the posterior inner tritor.

Form. & Loc. Cambridge Greensand: Cambridge.

Not represented in the Collection.

Ischyodus (?) incisus, Newton.

1878. *Ischyodus incisus*, E. T. Newton, *op. cit.* p. 38, pl. xii. figs. 3–10.

Type. Left mandibular tooth; British Museum.

A small species of doubtful generic position, the mandibular tooth apparently not attaining a greater antero-posterior measurement than 0·035–0·04. *Mandibular tooth* much compressed, with a deeply sinuous oral margin, acute eminences corresponding to the outer tritors, and the beak prominent; post-oral margin partly parallel with the symphysial margin; beak-tritor subdivided into a short series; anterior outer tritor small and narrow, the posterior one represented by a marginal series of minute tritors; median tritor very narrow and insignificant. [*Palatine tooth* unknown.] (?) *Vomerine tooth* relatively broad, prominently convex externally.

Form. & Loc. Albian: Kent. Cenomanian: Cambridgeshire. Turonian: Kent and Sussex.

41683. Left mandibular tooth, being the type specimen figured by Newton, *op. cit.* pl. xii. figs. 3–5; Lower Chalk, (?) Kent. *Toulmin-Smith Coll.*

47942–3. Left mandibular and vomerine teeth, figured by Newton, *op. cit.* pl. xii. figs. 6–8; Lower Chalk, Burham, Kent. *Presented by the Hon. Robert Marsham*, 1877.

The following dorsal fin-spines are of the form named *Leptacanthus* by Agassiz, *Auluxacanthus* by Sauvage, and *Chimæracanthus* by Quenstedt, and probably all pertain to species of *Ischyodus*:—

32728–30. Three imperfect spines of the form named *Leptacanthus longissimus*, Agassiz [1], and probably referable to *Ischyodus emarginatus*; Great Oolite, Caen, Normandy. *Tesson Coll.*

[1] Poiss. Foss. vol. iii. (1837), p. 29, pl. i. *a*, figs. 14–18.

P. 2214. Fragment of a similar spine; Caen. *Egerton Coll.*

27412. Small slender spine 0·059 in length; Oxford Clay, Christian Malford, Wiltshire. *Purchased*, 1852.

41877. Portion of large spine; Kimmeridge Clay, Weymouth. *Purchased*, 1869.

43558. Proximal half of large spine; Weymouth. *Purchased*, 1872.

P. 1159, P. 3098. Two portions of similar spines; Weymouth. *Egerton & Enniskillen Colls.*

36162-3. Large portions of two spines of the form named *Auluxacanthus dutertrei*, H. E. Sauvage, Catal. Poiss. Form. Second. Boulonnais (Mém. Soc. Acad. Boulogne, vol. ii. 1867), p. 65, pl. iii. fig. 1; Kimmeridge Clay, Boulogne-sur-Mer. *Purchased*, 1861.

P. 6036. Fragment; Portland Stone, Weymouth. *Presented by George Clifton, Esq.*, 1889.

47187, P. 34, P. 60. Four fragments and one nearly complete spine, probably of *Ischyodus thurmanni*; Gault, Folkestone. *Gardner Coll.*

The fragment of spine named *Chimæracanthus aalensis* by Quenstedt (Der Jura, 1858, p. 347, pl. xlvii. fig. 19) was obtained from the Brown Jura β of Würtemberg, and is now preserved in the Tübingen University Museum.

Another spine, from the Upper Trias of Lombardy, said to be of the same type as those mentioned above, is described under the name of *Leptacanthus cornaliæ*, C. Bellotti in A. Stoppani's Studii Geol. e Paleont. Lombardia (1858), p. 437. This, however, is evidently Hybodont, as pointed out by E. Cornalia, Giorn. R. Istit. Lombardo, vol. vi. (1854), p. 58, pl. ii. fig. 5.

The following species have also been founded upon detached teeth, of which there are no representatives in the Collection:—

Ischyodus aalensis, J. Riess, Palæontogr. vol. xxxiv. (1887), p. 19, pl. i. fig. 9: *Chimæra aalensis*, F. A. Quenstedt, Handb. Petrefakt. (1852), p. 185, pl. xiv. figs. 14–16, and Der Jura (1858), pp. 339, 347, pl. xlvii. figs. 21–28.—Brown Jura β; Würtemberg. [Tübingen University Museum.]

Ischyodus acutus, H. von Meyer, Palæontogr. vol. vii. (1859), p. 17, pl. ii. figs. 9–12.—Portlandian; Hanover. [Left vomerine tooth.]

Ischyodus beaugrandi, H. E. Sauvage, Catal. Poiss. Form. Second. Boulonnais (Mém. Soc. Acad. Boulogne-sur-Mer, vol. ii. 1867), p. 79, pl. iv. figs. 7, 8.—Kimmeridgian; Châtillon, Boulogne. [Mandibular tooth.]

Ischyodus bifurcati: *Chimæra bifurcati*, F. A. Quenstedt, Handb. Palæont. ed. 3 (1883), p. 293, pl. xxiii. fig. 25; J. Riess, Palæontogr. vol. xxxiv. (1887), p. 19.—Brown Jura δ; Würtemberg. [Fragmentary mandibular tooth (? = *I. aalensis*); Tübingen University Museum.]

Ischyodus dutertrei, Sir P. Egerton, Proc. Geol. Soc. vol. iv. (1843), p. 156 (*dutetrii*); H. E. Sauvage, *op. cit.* p. 89, pl. iii. figs. 17–19: *Chimæra dutetrii*, Sir P. Egerton, Ann. Mag. Nat. Hist. vol. xii. (1843), p. 469, and Proc. Geol. Soc. vol. iv. (1843), p. 154: *Chimæra* (*Ischyodon*) *dutertrii*, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 345.—Portlandian; Boulogne. [Mandibular tooth.]

Ischyodus ferrugineus, J. Riess, Palæontogr. vol. xxxiv. (1887), p. 20, pl. i. fig. 10, pl. iii. fig. 11.—Brown Jura β; Aalen, Würtemberg. [Mandibular tooth; Munich Museum.]

Ischyodus personati: *Chimæra personati*, F. A. Quenstedt, Handb. Petrefakt. ed. 1 (1852), p. 185, pl. xiv. fig. 17, and Der Jura (1858), p. 339, pl. xlvi. figs. 8, 9.—Brown Jura β; Würtemberg. [Fragmentary teeth; Tübingen University Museum.]

Ischyodus sauvagei, E. T. Hamy, Bull. Soc. Géol. France, [2] vol. xxiii. (1866), p. 655, woodc. fig. 2; H. E. Sauvage, Catal. Poiss. Form. Second. Boulonnais (Mém. Soc. Acad. Boulogne-sur-Mer, vol. ii. 1867), p. 86, pl. iv. figs. 2, 3.—Kimmeridgian; Boulogne. [Palatine tooth; Boulogne Museum.]

Ischyodus schuebleri, J. Riess, Palæontogr. vol. xxxiv. (1887), p. 17, pl. i. fig. 8: *Chimæra schuebleri*, F. A. Quenstedt, Der Jura (1858), p. 782, pl. xcvi. fig. 39: *Ischyodus* (*Chimæra*) *rostratus*, H. von Meyer, Palæontogr. vol. vii. (1859), p. 14, pl. ii. figs. 3–8.—White Jura ϵ; Würtemberg and Bavaria. Portlandian; Hanover. [Mandibular tooth; Tübingen University Museum.]

Ischyodus suprajurensis, H. E. Sauvage, *op. cit.* p. 75, pl. iv. fig. 13.—Kimmeridgian; Boulogne. [Imperfect mandibular tooth (? of *Ischyodus beaumonti*); Boulogne Museum.]

A Chimæroid egg from the Jurassic of Würtemberg, not improbably referable to *Ischyodus*, has also been described by E. Bessels, Württ. Jahresh. vol. xxv. (1869), p. 152, pl. iii.

Genus **EDAPHODON,** Buckland.

[Proc. Geol. Soc. vol. ii. 1838, p. 687[1].]

Syn. *Passalodon*, W. Buckland, *ibid.*
Psittacodon, L. Agassiz, Poiss. Foss. vol. iii. 1843, p. 340 (in part).
Eumylodus, J. Leidy, Extinct Vert. Fauna W. Territ. (Rep. U. S. Geol. Surv. Territ. vol. i. 1873), p. 309.
Dipristis, O. C. Marsh, Proc. Amer. Assoc. Adv. Sci. 1869, p. 230.

Mandibular tooth massive, with no definite thickening upon the outer aspect, and the symphysial facette very broad; one anterior tritor present, and sometimes a smaller one below it; one median tritor, occasionally divided longitudinally, and two external tritors. Palatine teeth very robust, with no well-defined thickening upon the outer aspect; three tritors present, two being inner and one outer. Vomerine tooth more or less triangular in side view, with tritors upon the oral margin; post-oral region laterally expanded, without any thickening.

The name of *Passalodon* was applied by Buckland to the vomerine teeth, and that of *Psittacodon* by Agassiz to the mandibular teeth of *E. mantelli* and *E. sedgwicki*.

Edaphodon sedgwicki (Agassiz).

1843. *Chimæra* (*Psittacodon*) *sedgwickii*, L. Agassiz, Poiss. Foss. vol. iii. p. 349, pl. xl. figs. 17, 18.
1843. *Ischyodus sedgwicki*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156.
1847. *Edaphodon sedgwicki*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iii. p. 352.
1850. *Edaphodon sedgwicki*, F. Dixon, Foss. Sussex, p. 203.
1864. *Edaphodus huxleyi*, H. G. Seeley, Ann. Mag. Nat. Hist. [3] vol. xiv. p. 276 (name only). [Fragmentary teeth; Woodwardian Museum, Cambridge.]
1878. *Edaphodon sedgwickii*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Monogr. iv.), p. 7, pls. i., ii.

Type. Imperfect right mandibular tooth; Mus. Geological Society of London.

A species attaining to a very large size, the measurement from the middle of the symphysial border to the extremity of the post-oral margin of the mandibular tooth being sometimes 0·15. *Mandibular tooth* with a very prominent beak, and the symphysial

[1] This genus was first satisfactorily defined by Egerton, Quart. Journ. Geol. Soc. vol. iii. (1847), p. 351, pl. xiii. figs. 2, 3.

facette occupying at least one third of the inner aspect; beak-tritor composed of a series of laminæ, the other tritors consisting of numerous tubules; median tritor divided [in unabraded specimens] into two small, widely-separated parts, of which the anterior is placed upon the edge of the symphysis, and the posterior behind the anterior outer tritor. *Palatine tooth* with very large tritors, the two inner being broad, and the posterior of these tending to overlap the narrow outer tritor. *Vomerine tooth* with a concave or grooved symphysial surface; the anterior tritor much larger than the others.

A specimen obtained by Mr. Charles Potter from the Chalk of Lewes, and described by Newton, *op. cit.*, makes known the complete dentition of this species.

Form. & Loc. Neocomian: Isle of Wight. Albian: Kent. Cenomanian: Cambridgeshire, Norfolk, and Kent. Turonian: Kent and Sussex. (?) Senonian: Norfolk.

(i.) *Gault, Folkestone.*

P. 23. Pair of mandibular teeth with very long beak. *Gardner Coll.*

47183, P. 24. Two right mandibular teeth, one being imperfect. *Gardner Coll.*

43604. Left mandibular tooth. *Purchased*, 1859.

P. 25. Pair of palatine teeth. *Gardner Coll.*

(ii.) *Cambridge Greensand, Cambridge.*

30252. Left mandibular tooth of moderate size. *Purchased*, 1855.

35136. Very robust, large right mandibular tooth. *Purchased*, 1859.

35399, 35400. Right and left mandibular teeth. *Purchased*, 1860.

47955–6. Two fragmentary mandibular teeth. *Presented by the Hon. Robert Marsham*, 1877.

P. 1144. Portion of a very large right mandibular tooth. *Egerton Coll.*

P. 3083–4. Small right mandibular tooth, and one of the left side very small. *Enniskillen Coll.*

P. 6004. Mandibular teeth, associated with the vomerine and palatine teeth of the right side. *Purchased*, 1889.

35134, 35137. Three imperfect palatine teeth. *Purchased*, 1859.

35401–2. Right and left palatine teeth. *Purchased*, 1860.

P. 1142. Left palatine tooth. *Egerton Coll.*

P. 3081. Right palatine tooth, and two imperfect specimens. *Enniskillen Coll.*

35132–3, 35151, 35370. Four vomerine teeth. *Purchased*, 1859.

39099, 39100. Right and left vomerine teeth. *Bowerbank Coll.*

46357–8. Left vomerine tooth and a small example of the right side. *Cunnington Coll.*

P. 1143. Two imperfect right vomerine teeth. *Egerton Coll.*

P. 3082. Three imperfect left vomerine teeth. *Enniskillen Coll.*

(iii.) *Red Chalk, Hunstanton.*

P. 4965. Very imperfect right vomerine tooth, doubtfully of this species. *Presented by J. E. Lee, Esq.*, 1885.

(iv.) *Chalk Marl, Dover.*

47184–5. Two small right mandibular teeth, probably of this species. *Gardner Coll.*

(v.) *Upper Chalk, Norwich.*

48944. Fragments of the dentition of one individual, including the nearly complete vomerine teeth, doubtfully assigned to this species by Newton, *op. cit.* p. 11. *Bayfield Coll.*

P. 414. A pair of mandibular teeth, the right vomerine, and fragments of the palatines, found associated and resembling the foregoing, though smaller. *Presented by S. T. Bayfield, Esq.*, 1881.

(vi.) *Chalk, Sussex.*

25746. Right mandibular tooth, probably of this species. *Dixon Coll.*

Edaphodon mantelli (Buckland).

1835. *Chimæra mantellii*, W. Buckland, Proc. Geol. Soc. vol. ii. p. 206.
1836. *Chimæra mantellii*, W. Buckland, Phil. Mag. [3] vol. viii. p. 5.
1843. *Ischyodus mantelli*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156.
1843. *Chimæra* (*Psittacodon*) *mantellii*, L. Agassiz, Poiss. Foss. vol. iii. p. 348, pl. xl. *a*. figs. 1, 2.
1847. *Edaphodon mantellii*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iii. p. 352.

1850. *Edaphodon mantelli*, F. Dixon, Foss. Sussex, p. 203, pl. xxxiv. figs. 6, 7.

1875. *Chimæra mantellii*, H. B. Geinitz, Palæontogr. vol. xx. pt. ii. p. 206, pl. xxxix. figs. 11, 12.

1878. *Edaphodon mantellii*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Monogr. iv.), p. 14, pl. iv. figs. 1–9.

Type. Mandibular teeth; British Museum.

A species not attaining so large a size as *E. sedgwicki*, but scarcely differing in the characters of the dentition. The *mandibular tooth* appears to be less robust than that of the latter species, and the tritors are often much narrower. In the *palatine tooth* also the posterior inner tritor is relatively longer and narrower.

Form. & Loc. Cenomanian, Turonian, and Senonian: Kent and Sussex. (?) Cenomanian: Cambridgeshire. Cenomanian: Saxony.

4280–1. Type specimens figured by Agassiz and Newton; Upper Chalk, Lewes, Sussex. *Mantell Coll.*

49729. Small left mandibular tooth; Lewes. *Capron Coll.*

P. 3085. Slender left mandibular tooth; Lewes. *Enniskillen Coll.*

P. 5405. Larger and stouter example of the same tooth; Lewes. *Presented by P. E. Coombe, Esq.*, 1888.

25891. Imperfect small right mandibular tooth; Chalk, Sussex. *Dixon Coll.*

49728. Small left mandibular tooth, figured by Newton, *op. cit.* pl. iv. fig. 9; Upper Chalk, Houghton, Arundel, Sussex. *Capron Coll.*

49724. Stouter example of the same tooth, doubtfully of this species; Chalk, Brighton, Sussex. *Capron Coll.*

25892. Portion of right mandibular tooth, figured by Dixon, *op. cit.* pl. xxxiv. fig. 7; Chalk, Sussex. *Dixon Coll.*

49018. Pair of mandibular teeth; English Chalk. *Mrs. Smith's Coll.*

41676, 41679. Right mandibular tooth noticed by Newton, *op. cit.* p. 16, and the anterior two thirds of a larger, more elongated, example of the left side; Upper Chalk, Kent. *Toulmin-Smith Coll.*

43128. Small right mandibular tooth; Chalk, Kent. *Wetherell Coll.*

49013. Imperfect right mandibular tooth, figured by Dixon, *op. cit.* pl. xxxiv. fig. 6; Kent. *Mrs. Smith's Coll.*

P. 316. More imperfect similar specimen, of the left side; Lower Chalk, Burham, Kent. *Harris Coll.*

P. 317. Very small right mandibular tooth, doubtfully of this species; Chalk, Hart Hill, Charing, Kent. *Harris Coll.*

P. 5619. Right mandibular tooth; Kent. *Harford Coll.*

36903. Pair of imperfect mandibular teeth; Grey Chalk, Dover. *Purchased*, 1862.

46359. Almost unabraded right mandibular tooth, probably of this species; Cambridge Greensand. *Cunnington Coll.*

41677, 41680. Left palatine tooth, and an imperfect pair of smaller palatine teeth; Chalk, Sussex. *Toulmin-Smith Coll.*

25894. Very small right palatine tooth, labelled by Agassiz as pertaining to this species; Sussex. *Dixon Coll.*

25860. Right vomerine tooth, probably of this species; Sussex. *Dixon Coll.*

49721. Small right palatine tooth, figured by Newton, *op. cit.* pl. iv. fig. 8, as probably referable to this species; Upper Chalk, Guildford. *Capron Coll.*

49722. Small right palatine tooth, doubtfully of this species, figured *ibid.* pl. iv. fig. 12; Lower Chalk, Glynde, Sussex. *Capron Coll.*

Some large vomerine teeth from the Chalk of Sussex, probably pertaining to one of the two last-described species, are named *Edaphodon gigas*, Egerton[1]. The following specimens are of this character:—

41678. Right vomerine tooth, figured by Newton, *op. cit.* pl. v. fig. 2; Chalk, Lewes. *Toulmin-Smith Coll.*

P. 1146. Fragment of left vomerine tooth, labelled by Egerton; Chalk, Sussex. *Egerton Coll.*

Edaphodon agassizi (Buckland).

1835. *Chimæra agassizii*, W. Buckland, Proc. Geol. Soc. vol. ii. p. 206.
1836. *Chimæra agassizii*, W. Buckland, Phil. Mag. [3] vol. viii. p. 5.
1843. *Ischyodus agassizi*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156.
1843. *Chimæra* (*Ischyodon*) *agassizii*, L. Agassiz, Poiss. Foss. vol. iii. p. 341, pl. xl. *a.* figs. 3, 4, (? 5), pl. xl. *c.* fig. 16 (*non* figs. 14, 15).

[1] Quart. Journ. Geol. Soc. vol. iii. (1847), p. 352. Also E. T. Newton, Mem. Geol. Surv., Monogr. iv. (1878), p. 17, pl. v. figs. 1, 2.—*Ischyodus gigas*, Egerton, Proc. Geol. Soc. vol. iv. (1843), p. 211; also F. Dixon, Foss. Sussex (1850), pl. xxxiv. fig 8.

1844. *Chimæra*, G. A. Mantell, Medals of Creation, p. 621.
1875. *Chimæra agassizii*, H. B. Geinitz, Palæontogr. vol. xx. pt. ii. p. 206, pl. xxxix. figs. 8–10.
1878. *Edaphodon agassizii*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Monogr. iv.), p. 12, pl. iii.

Type. Imperfect mandibular tooth ; British Museum.

Mandibular tooth comparatively short and robust, and the beak only slightly produced ; symphysial facette occupying less than one third of the inner aspect ; beak-tritor composed of a series of laminæ, the other tritors consisting of a number of tubules ; median tritor very broad, occupying the greater portion of the oral surface, and apparently exposed superiorly throughout its length. [Palatine and vomerine teeth unknown.]

Form. & Loc. Cenomanian and Turonian : Sussex, Kent, and Surrey. Cenomanian : Saxony.

28387. Type specimen, figured by Agassiz, *tom. cit.* pl. xl. *a*. figs. 3, 4, and by Newton, *op. cit.* pl. iii. figs. 1, 2 ; Chalk Marl, Hamsey, Sussex. *Mantell Coll.*

49723. Left mandibular tooth ; Lower Chalk, Southeram, near Lewes. *Capron Coll.*

P. 5406. More imperfect example ; Lewes.
Presented by P. E. Coombe, Esq., 1888.

28386. Pair of mandibular teeth, associated with dorsal fin-spine, noticed by Mantell (*op. cit.*), and figured by Newton, *op. cit.* pl. iii. fig. 3 ; Lower Chalk, Burham, Kent.
Mantell Coll.

P. 1154. Imperfect small right mandibular tooth, the symphysis either broken or unusually narrow ; Lower Chalk, Kent.
Egerton Coll.

41681. Imperfect left mandibular tooth, equally small ; Dorking, Surrey. *Toulmin-Smith Coll.*

4283. Imperfect small left palatine tooth, assigned to this species by Agassiz (*tom. cit.* pl. xl. *a*. fig. 5), but stated by Newton (*op. cit.* p. 13) to be too imperfect for determination ; Lewes. *Mantell Coll.*

Edaphodon crassus, Newton.

1878. *Edaphodon crassus*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Monogr. iv.), p. 21, pl. vii.

Type. Associated dentition ; Museum of Practical Geology.

A species of small size. *Mandibular tooth* short and robust, and

the beak not very prominent; symphysial facette occupying at least one third of the inner aspect; beak-tritor composed of a series of laminæ, with a minute tubulated tritor immediately above it; median tritor occupying the greater portion of the inner aspect, extending forwards to the symphysis and only slightly separated from the posterior outer tritor. *Palatine tooth* depressed, the oral surface almost covered by the tritors, of which the posterior inner one is especially broad.

Form. & Loc. Cenomanian: Cambridgeshire and Wiltshire. (?) Turonian: Sussex.

35145–6. Two right mandibular teeth, somewhat imperfect; Cambridge Greensand, Cambridge. *Purchased*, 1859.

35343, 35429. Two imperfect palatine teeth, right and left; Cambridge. *Purchased*, 1859.

P. 1145. Two palatine teeth, right and left; Cambridge. *Egerton Coll.*

P. 3088. Two more abraded palatine teeth, right and left; Cambridge. *Enniskillen Coll.*

Edaphodon reedi, Newton.

1878. *Edaphodon reedii*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Monogr. iv.), p. 19, pl. vi.

Type. Mandibular tooth, associated with palatine and vomerine teeth; Reed Collection, York Museum.

Mandibular tooth with a very prominent beak, and the symphysial facette occupying at least one third of the inner aspect; beak-tritor composed of a series of laminæ, the other tritors consisting of numerous tubules; median tritor with only a minute representative upon the edge of the symphysis; posterior outer tritor wanting. *Palatine tooth* with the posterior inner tritor very small or absent, and the outer smaller than the anterior inner tritor.

Form. & Loc. Cenomanian: Cambridgeshire.

35139. Small imperfect right mandibular tooth; Cambridge Greensand, Cambridge. *Purchased*, 1859.

46356. Pair of palatine teeth, the left being imperfect; Cambridge. *Cunnington Coll.*

35138, 35141, 35160. Three small palatine teeth, somewhat imperfect; Cambridge. *Purchased*, 1859.

49727. Right palatine tooth, regarded by Newton (*op. cit.* p. 21) as possibly of this species; Chalk, Glynde, Sussex. *Capron Coll.*

Edaphodon bucklandi, Agassiz.

1843. *Edaphodon bucklandi*, L. Agassiz, Poiss. Foss. vol. iii. p. 351, pl. xl. *d*. figs. 1–4, 9–12, 19–24.

1843. *Edaphodon eurygnathus*, L. Agassiz, *ibid.* p. 352. [Palatine teeth; British Museum.]

1850. *Edaphodon eurygnathus*, F. Dixon, Foss. Sussex, p. 111, pl. x. figs. 18, 19, 22, pl. xii. fig. 5.

1885. *Edaphodon bucklandi*, F. Noetling, Abh. geol. Specialk. Preussen u. Thüring. Staaten, vol. vi. pt. 3, p. 3, pl. i. fig. 1.

Type. Theoretically associated dentition of both jaws; British Museum (in part).

The type species, of large size, the mandibular tooth sometimes measuring 0·11 from the middle of the symphysial border to the extremity of the post-oral margin. *Mandibular tooth* robust, with a prominent beak, and the symphysial facette occupying more than one third of the inner aspect; beak-tritor mostly composed of laminæ, the other tritors consisting of numerous tubules; median tritor occupying more than two thirds of the inner oral surface, with a narrow band separated from it immediately upon the posterior border of the symphysis. *Palatine tooth* relatively broad, with large tritors, the posterior inner one being the largest and broadest and well separated from the outer tritor, which is much elongated and expands anteriorly. *Vomerine tooth* very robust, with a broad symphysial surface.

The differences between the palatine and vomerine teeth of this species and those of the so-called *E. eurygnathus* are solely due to the imperfect state of preservation of the type specimens of the latter.

Form. & Loc. Middle Eocene (Bagshot and Bracklesham Beds): Surrey and Sussex. Lower Eocene: Isle of Sheppey. Eocene (Zone A_1): Samland, Prussia.

25700. Left mandibular tooth; London Clay, Sheppey.
Dixon Coll.

25719, 25721. Two examples of the same tooth, one being more imperfect, the other nearly complete, but more slender; Bracklesham Beds, Bracklesham Bay, Sussex. *Dixon Coll.*

P. 3074–5. Five mandibular teeth; Bracklesham. *Enniskillen Coll.*

P. 5436. Left mandibular tooth; Bracklesham.
Presented by P. E. Coombe, Esq., 1888.

38870. Right palatine tooth, figured among the type specimens by Agassiz, *tom. cit.* pl. xl. *d*. figs. 19–24; Bracklesham (*not* Bagshot, as stated). *Bowerbank Coll.*

25696. Pair of palatine teeth, forming the type specimen of *E. eurygnathus* figured by Dixon, *op. cit.* pl. x. fig. 18; Bracklesham. *Dixon Coll.*

25695. Left palatine tooth; Bracklesham. *Dixon Coll.*

28081. Left palatine tooth; Bracklesham. *Presented by F. E. Edwards, Esq.*, 1852.

P. 1147. Inner portion of right palatine tooth; Bracklesham. *Egerton Coll.*

25673. Imperfect right vomerine tooth, figured by Dixon, *op. cit.* pl. x. fig. 19, under the name of *E. eurygnathus*; Bracklesham. *Dixon Coll.*

25727. Nearly perfect left vomerine tooth; Bracklesham. *Dixon Coll.*

38877. Similar specimen, though more abraded externally, figured by Dixon, *op. cit.* pl. xii. fig. 5, under the name of *E. eurygnathus*; Bracklesham. *Bowerbank Coll.*

38878-80. Similarly abraded right vomerine tooth, another scarcely abraded and stouter, and a fragment of one of the left side; Bracklesham. *Bowerbank Coll.*

P. 1149. Left vomerine tooth, much abraded externally; Bracklesham. *Egerton Coll.*

Edaphodon leptognathus, Agassiz.

1843. *Edaphodon leptognathus*, L. Agassiz, Poiss. Foss. vol. iii. p. 352, pl. xl. *d.* figs. 5–8, 13–18.
1847. *Edaphodon*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iii. p. 351, pl. xiii. figs. 2, 3.
1850. *Edaphodon leptognathus*, F. Dixon, Foss. Sussex, p. 111, pl. x. figs. 20, 21.

Type. Theoretically associated mandibular and palatine teeth; British Museum (in part).

A species closely related to *E. bucklandi*, but readily distinguished by the much greater slenderness of all the teeth.

Form. & Loc. Middle Eocene (Bagshot and Bracklesham Beds): Middlesex, Surrey, and Sussex. Upper Eocene (Barton Clay): Hampshire.

25699, 25723, 25725, 25730. Right mandibular tooth figured by Dixon, *op. cit.* pl. x. fig. 21, and three other mandibular teeth; Bracklesham. *Dixon Coll.*

24844. Left mandibular tooth; Bracklesham. *Purchased*, 1850.

28081 a. Similar specimen, wanting the extremity of the beak, and a right mandibular tooth; Bracklesham.
Presented by F. E. Edwards, Esq., 1852.

38873. Left mandibular tooth; Bracklesham. *Bowerbank Coll.*

Fig. 8.

Left mandibular tooth, inner aspect, of *Edaphodon leptognathus*, Ag.; Bracklesham Beds.

P. 1148. Two left mandibular teeth; Bracklesham. *Egerton Coll.*

P. 3077. Two small left mandibular teeth, and one of the right side; Bracklesham. *Enniskillen Coll.*

P. 5437. Small right mandibular tooth; Bracklesham.
Presented by P. E. Coombe, Esq., 1888.

38871. Right palatine tooth, figured as one of the type specimens by Agassiz, *tom. cit.* pl. xl. *d.* figs. 13–18; Goldsworthy Hill, Surrey. *Bowerbank Coll.*

25698, 25720, 25722, 25730 a. Right palatine tooth figured by Dixon, *op. cit.* pl. x. fig. 20, and three other palatine teeth; Bracklesham. *Dixon Coll.*

38872. Right palatine tooth; Bracklesham. *Bowerbank Coll.*

41299. Three imperfect palatine teeth; Bracklesham.
Purchased, 1869.

P. 1150 a. Left palatine tooth; Bracklesham. *Egerton Coll.*

P. 3078. Fragmentary similar tooth, and two smaller right palatine teeth; Bracklesham. *Enniskillen Coll.*

P. 5434. Large right palatine tooth; Bracklesham.
Presented by P. E. Coombe, Esq., 1888.

25732. Left vomerine tooth; Bracklesham. *Dixon Coll.*

P. 1150. Three small right palatine teeth ; Bracklesham.
Egerton Coll.

P. 1151. Portion of a similar tooth ; Bracklesham. *Egerton Coll.*

P. 5581. Imperfect right mandibular tooth, much abraded, probably of this species ; Red Crag (derived fossil), Woodbridge.
Harford Coll.

The following specimens may also, perhaps, pertain to this species :—

P. 6226. Fragment of inner side of left palatine tooth ; Lower Bagshot Beds, Hampstead, near London.
Presented by Robert Maitland, Esq., 1884.

P. 415. Left palatine tooth, with the tritors almost destroyed ; Thanet Sands, near Croydon, Surrey.
Presented by H. Turner, Esq., 1882.

Edaphodon (?) laminosus, Newton.

1878. *Edaphodon laminosus*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Monogr. iv.), p. 24, pl. viii.

Type. Right mandibular tooth ; British Museum.

Mandibular tooth robust, the beak being scarcely produced ; oral margin with traces of an external thickening layer ; symphysial facette broad, but occupying only about one quarter of the inner aspect ; beak-tritor and the anterior outer tritor laminated ; the symphysial extension of the very broad inner tritor also laminated, the hinder portion of this and the posterior outer tritor consisting of tubules. (?) *Palatine tooth* with the small posterior inner tritor of tubules, the outer and the anterior inner tritors larger and composed of laminæ.

As remarked by Newton, this imperfectly known species appears to be intermediate in its dentition between *Ischyodus* and *Edaphodon*.

Form. & Loc. Albian : Kent. Cenomanian : Cambridgeshire.

47182. Type specimen ; Gault, Folkestone. *Gardner Coll.*

The following specimen indicates an undetermined species of *Edaphodon* :—

P. 487. Fragment of the anterior portion of a right mandibular tooth, described by Agassiz (Poiss. Foss. vol. iii. 1843, p. 345, pl. xl. *c*. figs. 20, 21) as " maxillaire supérieur

droit," and regarded as the type of a Miocene species of *Ischyodus—Chimæra* (*Ischyodon*) *helvetica*; Molasse, Olten, Soleure, Switzerland. The specimen is referred to *Edaphodon* by F. J. Pictet, Paléontologie, ed. 2, vol. ii. (1854), p. 233. *Egerton Coll.*

The following dorsal fin-spines from the English Chalk may also be assigned to *Edaphodon*:—

39068. Slender spine, somewhat broken, 0·183 in length; Maidstone. *Bowerbank Coll.*

36749. Greater portion of similar spine; Halling, Kent. *Purchased*, 1862.

49731. Similar spine, wanting extremities; Lewes. *Capron Coll.*

P. 1153. Fragments of slender spine; Kent. *Egerton Coll.*

46401. Portion of stouter spine; Lower Chalk, Warminster, Wiltshire. *Cunnington Coll.*

43390. Portion of large spine; Burham, Kent. *Purchased*, 1872.

P. 6255. Fragments of large spine, provisionally assigned by Agassiz to *Edaphodon* ["*Chimæra*"] *mantelli* (Poiss. Foss. vol. iii. 1843, p. 64, pl. x. *b*. fig. 17); Lewes. *Mantell Coll.*

P. 3097. Basal portion of similar spine; Lewes. *Enniskillen Coll.*

49025–6. Portions of two large spines; locality uncertain. *Mrs. Smith's Coll.*

A dorsal fin-spine, probably of *Edaphodon*, has also been described from the Cretaceous of Central Russia by S. Nikitin, Mém. Comité Géol. vol. v. no. 2 (1882), p. 42, pl. iv. fig. 16. Another fin-spine, possibly of this genus, from the Cretaceous Greensand of New Jersey, is named *Sphagepœa aciculata*, E. D. Cope, Proc. Amer. Phil. Soc. vol. xi. (1869), p. 241.

The species mentioned below have also been determined upon the evidence of detached teeth, and, by a misunderstanding of the generic characters, the majority of the American forms have hitherto been ascribed to *Ischyodus*. Most of the type specimens of the latter are in the collection of Prof. E. D. Cope, Philadelphia, where the present writer has had the privilege of examining them; and many of the specific distinctions cited in the diagnoses would be regarded as varietal in Britain. Unless otherwise stated, the type specimen is a mandibular tooth:—

Edaphodon divaricatus: *Ischyodus divaricatus*, E. D. Cope, Proc. Boston Soc. Nat. Hist. 1869, p. 315, and Vert. Cret. Form. West (Rep. U. S. Geol. Surv. Territ. vol. ii. 1875), pp. 285, 292.—Cretaceous Greensand; New Jersey.

Edaphodon eocænus: *Ischyodus eocænus*, E. D. Cope, Vert. Cret. Form. West (1875), pp. 285, 288.—Eocene Greensand; Monmouth Co., New Jersey.

Edaphodon fecundus: *Ischyodus fecundus*, E. D. Cope, *ibid.* pp. 285, 290.—Cretaceous Greensand; New Jersey.

Edaphodon gaskilli: *Ischyodus gaskillii*, E. D. Cope, *ibid.* pp. 285, 290.—Ibid.

Edaphodon incrassatus: *Ischyodus incrassatus*, E. D. Cope, *ibid.* pp. 285, 289.—Ibid.

Edaphodon kelheimensis, J. Riess, Palæontogr. vol. xxxiv. (1887), p. 20, pl. i. fig. 11.—Greensand; Kelheim, Bavaria. [Palæontological Museum, Munich.]

Edaphodon laterigerus: *Ischyodus laterigerus*, E. D. Cope, Proc. Amer. Phil. Soc. vol. xi. (1871), p. 243, and Vert. Cret. Form. West (1875), pp. 284, 288.—Cretaceous Greensand; New Jersey.

Edaphodon longirostris: *Ischyodus longirostris*, E. D. Cope, Vert. Cret. Form. West (1875), pp. 284, 287.—Ibid.

Edaphodon miersi: *Dipristis miersii*, O. C. Marsh, Proc. Amer. Assoc. Adv. Sci. 1869, p. 230: *Ischyodus miersii*, E. D. Cope, Vert. Cret. Form. West (1875), pp. 285, 292.—Ibid. [Dorsal fin-spine; Yale College Museum, New Haven.]

Edaphodon mirificus, J. Leidy, Proc. Acad. Nat. Sci. Philad. 1856, p. 221, and Ext. Vert. Fauna W. Territ. (Rep. U.S. Geol. Surv. Territ. vol. i. 1873), p. 306, pl. xxxvii. figs. 6–12; E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv. 1878), p. 24: *Ischyodus mirificus*, E. D. Cope, Vert. Cret. Form. West (1875), pp. 285, 291.—Ibid. [Mandibular and palatine teeth; Rutger's College, New Brunswick, N.J.]

Edaphodon monolophus: *Ischyodus monolophus*, E. D. Cope, Proc. Boston Soc. Nat. Hist. 1869, p. 314.—Ibid.

Edaphodon smocki: *Ischyodus smockii*, E. D. Cope, *ibid.* p. 316.—Ibid.

Edaphodon stenobryus: *Ischyodus stenobryus*, E. D. Cope, Vert. Cret. Form. West (1875), pp. 284, 285.—Ibid.

Edaphodon tripartitus: *Ischyodus tripartitus*, E. D. Cope, *ibid.* pp. 284, 286: *Ischyodus mirificus*, E. D. Cope ("errore"), Proc. Boston Soc. Nat. Hist. 1869, p. 314.—Ibid.

The right vomerine tooth of a large species of *Edaphodon*, from the Cretaceous of Columbus, Mississippi, now in the Museum of the Academy of Natural Sciences, Philadelphia, is described as the mandibular tooth of a distinct genus and species, *Eumylodus laqueatus*, J. Leidy, Ext. Vert. Fauna W. Territ. (Rep. U.S. Geol. Surv. Territ. vol. i. 1873), p. 309, pl. xix. figs. 21, 22, pl. xxxvii. figs. 13, 14.

The genus *Diphrissa*, E. D. Cope (Vert. Cret. Form. West, 1875, p. 283), is founded upon a mandibular tooth differing only from that of the typical *Edaphodon* in the presence of a single outer tritor—a feature noted above in *Edaphodon reedi*. Two species are recognized from the Cretaceous Greensand of New Jersey, the type being *D. solidula*, previously named *Ischyodus solidulus* (E. D. Cope, Proc. Amer. Phil. Soc. vol. xi. 1869, p. 244). The description of the second species, *D. latidens*, Cope, accompanies the generic diagnosis; and both of the type specimens are in the Cope Collection, Philadelphia.

The following genera and species appear to the present writer to be probably founded upon indeterminable fragments of the teeth of *Edaphodon*. They were obtained from the Cretaceous Greensand of New Jersey, and are preserved in the Cope Collection:—

Bryactinus amorphus, E. D. Cope, Vert. Cret. Form. West (1875), p. 282.

Isotænia neocæsariensis, E. D. Cope, *ibid.* p. 293.

The following genus and species is founded upon a palatine and vomerine tooth, of which the former appears to be a broken Edaphodont tooth:—

Mylognathus priscus, J. Leidy, Proc. Acad. Nat. Sci. Philad. 1856, p. 312, and Trans. Amer. Phil. Soc. [2] vol. xi. (1859), p. 153, pl. xi. figs. 24–30.—Tertiary Lignite; Nebraska.

The following genus, with three species, is founded upon an imperfect mandibular tooth showing only an inner tritor. A palatine tooth having long, narrow, outer and inner tritors, is doubtfully associated with this:—

Leptomylus densus, E. D. Cope, Proc. Boston Soc. Nat. Hist. vol. xii. (1869), p. 313.—Greensand; New Jersey. [The type species; E. D. Cope Collection, Philadelphia.]

Leptomylus cooki, E. D. Cope, Proc. Amer. Phil. Soc. vol. xi. (1871), p. 384.—Greensand; New Jersey.

Leptomylus forfex, E. D. Cope, Vert. Cret. Form. West (Rep. U.S. Geol. Surv. Territ. vol. ii. 1875), p. 281.—Greensand; New Jersey.

Genus **CALLORHYNCHUS,** Gronow.

[Zoophylacium Gronov. 1763, pt. i. p. 31.]

Snout with a cartilaginous prominence, terminating in a cutaneous flap; tail heterocercal. Mandibular tooth more or less massive, with a well-defined thick band upon the outer aspect immediately below the oral margin; anterior and outer tritors absent or minute; median tritor well developed. Palatine tooth robust, with a well-defined thickening upon the outer aspect immediately above the oral margin; a single large tritor, bifurcated anteriorly, occupying the greater part of the oral surface. Vomerine teeth more or less quadrate in side view. Dorsal fin-spine laterally compressed, smooth or longitudinally striated, with a double series of posterior denticles. Head-spine of male short, arched, with a terminal cluster of denticles.

Callorhynchus hectori, Newton.

1876. *Callorhynchus hectori*, E. T. Newton, Quart. Journ. Geol. Soc. vol. xxxii. p. 329, pl. xxi. figs. 6–9.

1878. *Callorhynchus hectori*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Monogr. iv.), p. 41, pl. xii. figs. 11, 12.

1888. *Callorhynchus hectori*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. iv. p. 41, pl. vii. figs. 14, 15.

Type. Right palatine tooth; British Museum.

Palatine tooth slightly differing from that of the recent *C. antarcticus* in the more forward production of the two divisions of the tritor.

Form. & Loc. "Lower Greensand:" Amuri Bluff, New Zealand.

P. 2301. Type specimen. *By exchange*, 1876.

Genus **ELASMODECTES**, Newton[1].

[Mem. Geol. Survey, Monogr. iv. 1878, p. 43.]

Mandibular tooth much laterally compressed, with no definite thickening upon the outer aspect, and the symphysial facette very narrow; anterior tritor divided into minute points; median tritor absent; outer tritors represented by marginal series of minute points.

The upper teeth are still unknown.

Elasmodectes willetti, Newton.

1878. *Elasmognathus willettii*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., Monogr. iv.), p. 43, pl. xii. figs. 13–15.

1888. *Elasmodectes willettii*, A. S. Woodward, Proc. Geol. Assoc. vol. x. p. 301.

Type. Associated right and left mandibular teeth; Willett Collection, Brighton Museum.

The single known species, of small size, the mandibular tooth measuring not more than 0·025 in length.

Form. & Loc. Turonian: Sussex and Kent.

47944. Imperfect right mandibular tooth, inner aspect, noticed by Newton, *op. cit.* p. 44; Lower Chalk, Burham, Kent. *Presented by the Hon. Robert Marsham*, 1877.

49022, 49024. Left and right mandibular teeth, noticed, *ibid.*; Burham. *Mrs. Smith's Coll.*

Genus **ELASMODUS**, Egerton.

[Proc. Geol. Soc. vol. iv. 1843, p. 156.]

Mandibular tooth much compressed, with no definite thickening upon the outer aspect, and the symphysial facette narrow; one large, laminated, anterior tritor present, with one or two minute ones below it upon the symphysis; one large median tritor; anterior outer tritor almost or completely fused with the postero-superior angle of the median; posterior outer tritor laminated and divided into several small parts. Palatine tooth very robust, with no well-defined thickening upon the outer aspect; four tritors represented,

[1] This genus was defined by Newton under the preoccupied name of *Elasmognathus*, and the modification here adopted was suggested by the present writer, Proc. Geol. Assoc. vol. x. (1888), p. 301.

the anterior and posterior inner being fused together, the median very large and sometimes fused with the posterior inner, and the outer tritor much elongated, consisting of laminæ. Vomerine tooth broad, with several closely-arranged, laminated tritors.

Elasmodus hunteri, Egerton.

1840. 'Extinct *Chimæra*,' R. Owen, Odontography, vol. i. p. 66.
1843. *Elasmodus hunteri*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156.
1847. *Elasmodus hunteri*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iii. p. 351.
1850. *Elasmodus hunteri*, F. Dixon, Foss. Sussex, p. 111, pl. x. figs. 11, 12.
1852. *Elasmodus hunteri*, Sir P. Egerton, Figs. and Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. vi. no. 1, pl. i.
1885. *Elasmodus hunteri*, F. Noetling, Abh. geol. Specialk. Preussen u. Thüring. Staaten, vol. vi. pt. 3, p. 11, pl. i. figs. 2, 3, pl. ii. fig. 6.

Type. Mandibular tooth and theoretically associated vomerine tooth; Royal College of Surgeons.

The type species. Inner tritor of mandibular tooth at least as broad as the space between it and the symphysis, sometimes much broader. Median and outer tritors of the palatine tooth extremely elongated antero-posteriorly.

Form. & Loc. Lower Eocene (London Clay): Isle of Sheppey. Middle Eocene (Bracklesham Beds): Sussex. Eocene (Zone A_1): Samland, Prussia.

(i.) *London Clay; Isle of Sheppey.*

40203. Left mandibular tooth. *Purchased*, 1867.

43110. Similar specimen, less abraded. *Wetherell Coll.*

44910. Imperfect right mandibular tooth. *Presented by Sir Richard Owen, K.C.B.*, 1874.

P. 161. Small abraded left mandibular tooth. *Purchased*, 1880.

P. 6227. Abraded left palatine tooth. *History unknown.*

P. 3080 a. Imperfect right palatine tooth. *Enniskillen Coll.*

P. 1157 a. Left vomerine tooth. *Egerton Coll.*

(ii.) *Bracklesham Beds; Bracklesham Bay, Sussex.*

P. 6228. Small left mandibular tooth, figured by Egerton, *op. cit.* (1852), pl. i. figs. 3, 4. *Dixon Coll.*

P. 6229. Much abraded fragmentary left mandibular tooth. *Dixon Coll.*

38869. Left mandibular tooth, figured by Dixon, *op. cit.* *Bowerbank Coll.*

P. 6230. Two examples of the right palatine tooth, figured by Egerton, *op. cit.* (1852), pl. i. figs. 5–8. *Dixon Coll.*

Elasmodus greenoughi, Agassiz.

1843. *Elasmodus greenovi*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156 (name only).

1843. *Elasmodus greenoughii*, L. Agassiz, Poiss. Foss. vol. iii. p. 350, pl. xl. figs. 11–16.

Type. Imperfect right mandibular tooth; British Museum.

Inner tritor of mandibular tooth considerably narrower than the space between it and the symphysis.

Form. & Loc. Upper Senonian: Belgium.

P. 483. Type specimen figured by Agassiz, *tom. cit.* pl. xl. figs. 11, 12; locality unknown, but probably from the Poudingue de Malogne, Ciply, near Mons, Belgium. *Egerton Coll.*

P. 3079. Two fragments of right mandibular teeth, in similar condition, one figured by Agassiz, *op. cit.* pl. xl. figs. 15, 16. *Enniskillen Coll.*

P. 5837. Imperfect left mandibular tooth, wanting symphysis; Ciply. *Presented by Mons. A. Houzeau de Lehaie*, 1888.

P. 483 a. Fragment of tooth, in similar condition to the type specimen, determined to be vomerine by Agassiz, *tom. cit.* p. 350, pl. xl. figs. 13, 14, but probably the symphysial region of the mandibular tooth. *Egerton Coll.*

Closely related to *Elasmodus* is the fragmentary tooth named thus:—

Psaliodus compressus, Sir P. Egerton, Proc. Geol. Soc. vol. iv. (1843), p. 157.—(?) London Clay: Sheppey. [Mandib. tooth; Royal College of Surgeons, London.]

Genus **CHIMÆRA**, Linnæus.

[Syst. Nat. ed. 12, vol. i. 1766, p. 401.]

Syn. (?) *Dipristis*, P. Gervais, Zool. et Pal. Gén. 1869, p. 240.

Snout soft, prominent, without appendage; tail diphycercal. Mandibular tooth laterally compressed, with no well-defined thickening upon the outer aspect immediately below the oral margin, and the symphysis narrow; anterior tritor minute, anterior outer tritor subdivided into two or three small portions, posterior outer tritor similar; median tritor large. Palatine tooth moderately robust, with a slightly defined thickening upon the outer aspect; anterior and posterior inner tritors small; median tritor small; outer tritor extending throughout the oral margin, subdivided into a series of small points. Vomerine tooth quadrate in side view. Dorsal fin-spine laterally compressed, smooth or longitudinally striated, with a double series of posterior denticles. Head-spine of male short, arched, with a terminal cluster of denticles.

Chimæra pliocenica, sp. nov.

[Plate I. fig. 15.]

Type. Right palatine tooth; British Museum.

A very large species, the antero-posterior measurement of the palatine tooth being not less than 0·025. Palatine tooth comparatively robust; posterior inner and median tritors of about equal size; anterior inner tritor small and narrow, fixed upon the downwardly-curved anterior extremity of the tooth.

Teeth probably for the most part referable to this species have been determined as *Ischyodus egertoni*, *Edaphodon mantelli*, *E. bucklandi*, and *E. leptognathus* (R. Lawley, Nuovi Studi Pesci, etc. Colline Toscane, 1876, p. 51).

Form. & Loc. Pliocene: Tuscany.

47032. Type specimen, shown of the natural size, from three aspects, in Pl. I. fig. 15, *a–c*; Orciano, Tuscany.

Purchased, 1875.

A small species has also been described as follows:—

Chimæra javana, K. Martin, Samml. geol. Reichs-Museum Leiden [1] vol. iii. (1883), p. 30, pl. ii. figs. 25, 26.—Tertiary; Ngembak, Java. [Upper teeth; Leyden Museum.]

The original of the following specimen is also referable to a large extinct species either of *Chimæra* or *Edaphodon* :—

P. 1160. Plaster cast of imperfect dorsal fin-spine, described and figured under the name of *Dipristis chimæroides*, P. Gervais, Zool. et Pal. Générales (1867–69), p. 241, pl. xlvi. fig. 5; Miocene, Léognan, Gironde. *Egerton Coll.*

Either to *Chimæra* or *Edaphodon* may be assigned the fragments of teeth from the Molasse of Baltringen, Würtemberg, named *Chimæra deleta*, J. Probst, Württ. Jahresh. vol. xxxviii. (1882) p. 131, pl. ii. fig. 17.

The so-called *Chimæra furcata*, A. Fritsch (Rept. u. Fische böhm. Kreideform. 1878, p. 16, woodc.), from the Cretaceous of Bohemia, is founded upon one of the problematical teeth named *Plethodus* by Dixon (Foss. Sussex, 1850, p. 366). The type specimen is preserved in the Royal Bohemian Museum, Prague, and has been examined by the present writer.

It is interesting to add that a small Chimæroid fish, exhibiting the typical dentition of the Chimæridæ, but destitute of a rostral spine both in the male and female, has lately been discovered in the deep sea off the Atlantic coast of North America. The genus is named *Harriotta* by Goode and Bean (Proc. Biol. Soc. Washington, vol. iii. 1886, p. 104, footnote), and the type specimens are preserved in the Smithsonian Institution.

ICHTHYODORULITES.

The characters of the dermal spines and tubercles of cartilaginous fishes vary so much in the different genera, and are sometimes so completely identical when other parts are quite distinct, that all fossils of this nature hitherto only discovered in an isolated condition may be conveniently grouped together under the denomination of Ichthyodorulites. The term was first employed by Buckland and De la Beche, who were the earliest to discover the true nature of these fossils; it was subsequently applied by Agassiz (*op. cit.*) to all fossil spines of Elasmobranch and Chimæroid fishes, whether correlated with the teeth or not; and we now propose to restrict the name to those detached dermal spines, tubercles, and plates which exhibit the microscopical structure of vascular dentine, and are thus

probably referable, for the most part, to one or the other of the subclasses just mentioned, but cannot yet be precisely determined.

The various "genera" already recognized may be briefly defined and discussed; but, although it is convenient to adopt provisional specific names for such fossils, future discoveries may soon lead to a more precise systematic allocation of most of the forms, and it will thus suffice merely to refer to the published diagnoses, without repeating them.

For convenience of reference, it is proposed to arrange the Ichthyodorulites in five groups, as follows:—

I. Slender elongated spines, bilaterally symmetrical, the inserted portion smooth and usually sharply separated from the ornamented exserted portion; internal cavity open posteriorly towards the base. Resembling the dorsal fin-spines of the Cestraciontidæ, and probably for the most part referable to that family and to the Cochliodontidæ.

Onchus, *Ctenacanthus*, *Anaclitacanthus*, *Eunemacanthus*, *Homacanthus*, *Hoplonchus*, *Acondylacanthus*, *Asteroptychius*, *Cosmacanthus*, *Bythiacanthus*, *Glymmatacanthus*, *Thaumatacanthus*, *Chalazacanthus*, *Lispacanthus*, *Lepracanthus*, *Nemacanthus*, (?) *Psilacanthus*.

II. Slender elongated spines, bilaterally symmetrical, with the internal cavity only open at the base, and little or no smooth inserted portion.

Gnathacanthus, *Apateacanthus*, *Pristacanthus*, *Cœlorhynchus*.

III. Paired spines, of which some may have been placed in front of fins, but of which many are broad, with insignificant base of insertion, and must have been arranged as independent dermal armour.

Machæracanthus, *Haplacanthus*, *Heteracanthus*, *Psammosteus*, *Stethacanthus*, *Physonemus*, (?) *Batacanthus*, *Stichacanthus*, *Oracanthus*, *Antacanthus*, *Gyracanthus*, *Aganacanthus*.

IV. Spines probably not placed in advance of fins, but most nearly resembling the head-spines of the male Chimæroids and some Mesozoic Cestraciont Sharks (*e. g. Hybodus*).

Erismacanthus, *Gampsacanthus*, *Lecracanthus*, *Dipriacanthus*, *Listracanthus*, *Byssacanthus*, *Cyrtacanthus*, *Euacanthus*, *Harpacanthus*, *Ostracacanthus*.

V. Dermal defences of doubtful position.

Edestus, *Cynopodius*, *Euctenius*.

I. Slender elongated spines, bilaterally symmetrical; the inserted portion smooth and usually sharply separated from the ornamented exserted portion; internal cavity open posteriorly towards the base. Resembling the dorsal fin-spines of the Cestraciontidæ, and probably for the most part referable to that family and to the Cochliodontidæ.

Genus **ONCHUS,** Agassiz.

[Poiss. Foss. vol. iii. 1837, p. 6.]

Syn. *Archæacanthus,* G. Kade, Programm. k. Realschule zu Meseritz, 1858, p. 19.

Spines of small size, laterally compressed; sides of exserted portion ornamented with smooth or faintly crenulated longitudinal ridges; no posterior denticles.

Onchus murchisoni, Agassiz.

1837. *Onchus murchisoni,* L. Agassiz, Poiss. Foss. vol. iii. p. 6, pl. i. fig. 1 (? *non* fig. 2).

1839. *Onchus murchisoni,* L. Agassiz, in Murchison's Silur. Syst. p. 607, pl. iv. figs. 9, 11 (? *non* fig. 10).

1853. *Leptocheles murchisoni,* F. M'Coy, Quart. Journ. Geol. Soc. vol. ix. p. 14.

1853. *Onchus murchisoni,* J. W. Salter, in Murchison, Quart. Journ. Geol. Soc. vol. ix. p. 16.

Type. Olim Murchison Collection.

The type species, regarded by M'Coy as founded upon fragments of Crustacean appendages, but stated by Salter to be undoubtedly based in part upon fish-spines. The type specimens are unfortunately lost [1], but the spines enumerated below exhibit the characters described by Agassiz.

Form. & Loc. Upper Ludlow: Herefordshire, Shropshire, and Radnorshire. Lower Old Red Sandstone: Herefordshire [2].

42250–1. Two fragments; Upper Ludlow, Linley Brook.
Baugh Coll.

[1] Murchison, Quart. Journ. Geol. Soc. vol. ix. 1853, p. 16.

[2] Doubtful specimens from the Upper Silurian of the Isle of Oesel, and the Devonian of N.W. Russia, are also assigned to this species by C. H. Pander, Foss. Fische Silur. Syst. (1856) p. 70, pl. iv. fig. 20, pl. vi. figs. 26, 27, and E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1594. A fragmentary spine much resembling this species, from Öfvedskloster, Scania, is also preserved in the State Museum, Stockholm.

42257. Fragment in bone-bed; Ludlow. *Baugh Coll.*

P. 5085. Portion of Ludlow bone-bed, with several fragments of spines; Norton, near Craven Arms.
Presented by J. E. Lee, Esq., 1885.

45978. Imperfect spine; L. Old Red Sandstone, Bush Pitch, Ledbury, Herefordshire. *Lightbody Bequest.*

P. 2249. Imperfect spine and fragment; L. Old Red Sandstone, Ledbury. *Egerton Coll.*

P. 2868, P. 3124. Fragment, and block of sandstone with numerous fragments; L. Old Red Sandstone, Ledbury.
Enniskillen Coll.

Onchus tenuistriatus, Agassiz.

1837. *Onchus tenuistriatus*, L. Agassiz, Poiss. Foss. vol. iii. p. 7, pl. i. fig. 10.
1837. *Onchus semistriatus*, L. Agassiz, *ibid.* p. 8, pl. i. fig. 9.
1839. *Onchus tenuistriatus*, L. Agassiz, in Murchison's Silur. Syst. p. 607, pl. iv. figs. 12, 13, 57–59.
1839. *Onchus semistriatus*, L. Agassiz, *ibid.* p. 596, pl. ii. figs. 12, 13.
1845. *Onchus semistriatus*, L. Agassiz, Poiss. Foss. V. G. R. p. 118, pl. xxxiii. fig. 37.
(?) 1885. *Onchus tenuistriatus*, F. Roemer, Palæont. Abhandl. vol. ii. p. 358, pl. xxxi. fig. 19.

Type. Olim Murchison Collection.

The examples of this species recorded below indicate that the fragment named *O. semistriatus* is a portion of the distal half of the spine, in which the smooth posterior area becomes relatively very large.

Form. & Loc. Upper Ludlow and Downton Sandstone: Herefordshire. Lower Old Red Sandstone: Herefordshire [1].

P. 5090. Imperfect spine; Downton Sandstone, Kington.
Presented by J. E. Lee, Esq., 1885.

45975–76. Basal half of spine, and imperfect impression of another; L. Old Red Sandstone, Bush Pitch, Ledbury, Herefordshire. *Lightbody Bequest.*

P. 2249 a. Imperfect spine; Ledbury. *Egerton Coll.*

P. 2865–66. Five spines, one associated with a fragment of a similar spine; Ledbury. *Enniskillen Coll.*

[1] Doubtful specimens from the Devonian of Slawjanka, near Pawlowsk, St. Petersburg, are also described by E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1595, pl. lv. fig. 7.

P. 6027. Gutta-percha cast of specimen assigned to this species by Roemer, *loc. cit.*, differing only from the typical spines in the apparent absence of the smooth posterior area distally; original in the Museum of the University of Breslau, and obtained from a boulder, Lyck, East Prussia.
Presented by Prof. Ferdinand Roemer, 1889.

Onchus quadrisulcatus (Kade).

1858. *Archæacanthus quadrisulcatus*, G. Kade, Programm. k. Realschule zu Meseritz, p. 19, figs. 11, 12.
1885. *Archæacanthus quadrisulcatus*, F. Roemer, Palæont. Abhandl. vol. ii. p. 386, pl. xxxiv. fig. 22.

Type species of *Archæacanthus*.
Form. & Loc. Devonian Boulders: Prussia and Silesia.

P. 6028. Gutta-percha cast of specimen figured by Roemer; original from Lyck, E. Prussia, preserved in the Breslau University Museum. *Presented by Prof. Ferdinand Roemer*, 1889.

Onchus (?) granulatus, Roemer.

1885. *Onchus granulatus*, F. Roemer, Palæont. Abhandl. vol. ii. p. 358, pl. xxxi. fig. 18.

Type. University of Breslau.
Form. & Loc. Upper Silurian (Beyrichien-Kalk); unknown.

P. 6026. Gutta-percha cast of type specimen; original from boulder near Nieder-Kunzendorf, near Freiburg, Silesia.
Presented by Prof. Ferdinand Roemer, 1889.

The following spine has been assigned to *Onchus*, but is not sufficiently well preserved for satisfactory determination. In many respects the specimen is suggestive of *Machæracanthus*.

P. 2864. Type specimen of *Onchus major*, Etheridge, described in Rep. Brit. Assoc. 1871, Trans. Sect. p. 110; Lower Old Red Sandstone, Llidiart-y-Warn Quarry, near Hay, Brecon. *Enniskillen Coll.*

The following species have also been described, but there are no examples in the Collection, and some may be mere fragments of Crustacea:—

Onchus clintoni, E. W. Claypole, Quart. Journ. Geol. Soc. vol. xli. (1885), p. 61, woodc. fig. 6.—Clinton Group; Perry Co., Pennsylvania.

Onchus curvatus, C. H. Pander, Foss. Fische Silur. Syst. (1856), p. 70, pl. vi. fig. 29.—Upper Silurian; Baltic Provinces.

Onchus dubius, C. H. Pander, *ibid.* p. 71, pl. vi. fig. 28.—Ibid.

Onchus pennsylvanicus, E. W. Claypole, *tom. cit.* (1885), p. 61, woodc. fig. 5.—Bloomfield Sandstone; Perry Co., Pennsylvania.

Onchus sublævis, L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 118, pl. xxxiii. figs. 19–21. [Doubtfully assigned to *O. murchisoni* by E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1595.]—Devonian; St. Petersburg.

Two doubtful *Onchus*-shaped fossils from the Lower Old Red Sandstone of Abergavenny, Monmouthshire, are named *Ptychacanthus dubius*, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 176, and Poiss. Foss. V. G. R. (1845), p. 118, pl. xxxiii. figs. 22, 23.

Very doubtful are *Onchus compressus*, E. von Eichwald (Leth. Rossica, vol. i. 1860, p. 1595), previously figured without specific name in Keyserling, Reise in das Petschoraland (1846), p. 291, pl. xxi. fig. *a*, from so-called Permian, Kischerma, Petchora-Land; and *O. tricarinatus*, C. H. Pander (*op. cit.* p. 71, pl. vi. fig. 30), from the Silurian of the Baltic Provinces.

The so-called *O. deweyi*, J. Hall (Palæont. New York, vol. ii. 1852, p. 320, pl. lxxi. fig. 1), is a fragment of the Crustacean *Ceratiocaris*; it was obtained from the Niagara Group of Lockport and Rochester, New York State.

Another Devonian Ichthyodorulite, apparently related to *Onchus*, has also been named as follows:—

Naulas, L. Agassiz (Poiss. Foss. V. G. R. 1845, p. 116), with one species, *N. sulcatus*, Agassiz (*ibid.* p. 116, pl. xxxiii. fig. 10), from St. Petersburg.

A very doubtful Devonian Ichthyodorulite from Petchora-Land is also named *Dimeracanthus concentricus*, A. von Keyserling, Reise in das Petschoraland (1846), p. 292 *b*; and another from the Government of Orel is termed *Pycnacanthus*, G. Fischer de Waldheim, Bull. Soc. Imp. Nat. Moscou, vol. xxv. (1852), pt. i. p. 174, pl. ii. fig. 10.

Genus **CTENACANTHUS**, Agassiz.

[Poiss. Foss. vol. iii. 1837, p. 10.]

Dorsal fin-spines robust, often attaining to a large size, laterally compressed; sides of exserted portion ornamented with longitudinal ridges, usually crenulated or denticulated, rarely smooth; posterior

face flat or concave, with a series of small denticles upon each margin.

Spines of this character doubtless characterize more than one genus. They have already been discovered in association with hybodont teeth, indicating a shark with two armed dorsal fins [1]; but they are also abundantly met with in beds where no such teeth occur. Agassiz [2] supposed that they were the spines of *Psammodus*; some palæontologists have suggested [3] that they may be correlated with the teeth named *Cladodus*, though at the same time erroneously identifying certain Coal-Measure fossils with these; and Dr. J. S. Newberry suspects [4], from a discovery in the Waverly Shales of Ohio, that *Ctenacanthus* and *Orodus* may be synonymous. It is certainly noteworthy that in Britain the largest spines of this type occur in the Bristol Carboniferous Limestone, where also are discovered the largest teeth of *Orodus*; and the "species" are most numerous at Armagh, where *Orodus* exhibits the greatest variety.

Ctenacanthus major, Agassiz.

1837. *Ctenacanthus major*, L. Agassiz, Poiss. Foss. vol. iii. p. 10, pl. iv.
1837. *Ctenacanthus tenuistriatus*, L. Agassiz, *ibid.* p. 11, pl. iii. figs. 7–11. [Bristol Museum and British Museum.]
1850. *Ctenacanthus tenuirostris*, F. A. Roemer, Palæontogr. vol. iii. p. 53, pl. viii. fig. 18 (misprint).
1878. *Ctenacanthus tenuistriatus*, L. G. de Koninck, Faune Calc. Carb. Belg. pt. i. p. 67, pl. vii. fig. 2.
(?) 1878. *Ctenacanthus maximus*, L. G. de Koninck, *ibid.* p. 68, pl. vii. fig. 1. [Brussels Museum.]
1883. *Ctenacanthus major*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 334, pl. xlii. figs. 1, 2.
1883. *Ctenacanthus tenuistriatus*, J. W. Davis, *ibid.* p. 335, pl. xliii. figs. 1, 2.
1883. *Ctenacanthus salopiensis*, J. W. Davis, *ibid.* p. 339, pl. xliv. fig. 6. [British Museum.]

Type. Bristol Museum.

The type species, attaining a very large size.

Form. & Loc. Lower Carboniferous Limestone: Gloucestershire and Belgium. Carboniferous Limestone: Shropshire. Lower Carboniferous (Posidonomyen-Schiefer): Upper Harz [5].

[1] See *Sphenacanthus*, Pt. I. p. 241. [2] Poiss. Foss. vol. iii. p. 171.
[3] Hancock & Atthey, Ann. Mag. Nat. Hist. [4] vol. ix. (1872), p. 260; J. Thomson, Trans. Glasgow Geol. Soc. vol. iv. (1871), p. 59.
[4] Rep. Geol. Survey Ohio, vol. ii. pt. ii. (1875), p. 54.
[5] A fragmentary spine, of doubtful species, from the Lower Carboniferous Limestone of the Govt. of Toula, is also named *Ctenacanthus major*, H. Trautschold, Nouv. Mém. Soc. Imp. Nat. Moscou, vol. xiii. p. 273, pl. xxvii. fig. 18.

P. 2534. Spine figured by J. W. Davis, *loc. cit.* pl. xlii. fig. 1; Bristol. *Enniskillen Coll.*

P. 3113–16. Three imperfect spines, and a fragment of the base of another bearing Agassiz's MS. label; Bristol. *Enniskillen Coll.*

P. 4201. Polished fragment; Bristol. *Enniskillen Coll.*

P. 2224. Three imperfect spines; Bristol. *Egerton Coll.*

41082. Polished fragment; Bristol. *Presented by J. J. Bennett, Esq.*, 1868.

The following specimens appear to differ from the foregoing only in their smaller size:—

P. 495, P. 2225. Imperfect terminal half of exserted portion of spine, being one of the type specimens of *C. tenuistriatus* figured by Agassiz, *tom. cit.* pl. iii. fig. 7; Bristol. The other portion of this fossil is in the Bristol Museum. *Egerton Coll.*

P. 3109. Spine assigned to *C. tenuistriatus* by J. W. Davis, *loc. cit.* pl. xliii. fig. 1; Bristol. *Enniskillen Coll.*

P. 3110. Half of spine in longitudinal section, polished, and labelled in Agassiz's handwriting thus:—"Probablement le rayon des dents nommées *Psammodus porosus*, décrit sous le nom de *Ctenacanthus tenuistriatus*, Ag."; Bristol. *Enniskillen Coll.*

P. 2522. Fragment; Bristol. *Enniskillen Coll.*

22665. Basal half of spine; Bristol. *Purchased.*

P. 2523. Type specimen of *Ctenacanthus salopiensis*, J. W. Davis; Oreton, Shropshire. *Enniskillen Coll.*

42238. Short stout spine; Oreton. *Baugh Coll.*

P. 213. Spine, imperfect distally; Oreton. *Weaver-Jones Coll.*

42233. Several fragments; Oreton. *Baugh Coll.*

36466. Fragment; Oreton. *Presented by G. E. Roberts, Esq.*, 1862.

42239. Fragment, with very large anterior longitudinal ridges, probably assignable to *C. major*; Oreton. *Baugh Coll.*

Ctenacanthus denticulatus, M'Coy.

1848. *Ctenacanthus denticulatus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 116.
1855. *Ctenacanthus denticulatus*, F. M'Coy, Brit. Palæoz. Foss. p. 625 pl. iii. K. fig. 16.
1883. *Ctenacanthus denticulatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 338, pl. xliv. fig. 4.

Type. Woodwardian Museum, Cambridge.
Form. & Loc. Lower Carboniferous Limestone: Armagh and Shropshire. Lower Carboniferous: Monaduff, Drumlish, N. Ireland.

41193–94. Two imperfect small spines; Oreton, Shropshire. *Purchased*, 1868.

42237. Fragment; Oreton. *Baugh Coll.*

Ctenacanthus brevis, Agassiz.

1837. *Ctenacanthus brevis*, L. Agassiz, Poiss. Foss. vol. iii. p. 11, pl. ii. fig. 2.
1883. *Ctenacanthus brevis*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 337, pl. xliii. fig. 3.
1883. *Ctenacanthus limaformis*, J. W. Davis, *ibid.* p. 339, pl. xliv. fig. 5. [British Museum.]

Type. Bristol Museum.
Form. & Loc. Lower Carboniferous Limestone: Bristol.

22665. Two partially broken spines, naturally associated, the hinder being smaller and narrower than the foremost. *Purchased*, 1848.

34982. Imperfect example. *Purchased*, 1860.

P. 2226. Spine, and fragment labelled by Agassiz. *Egerton Coll.*

P. 3111–2. Spine figured and described by J. W. Davis, *tom. cit.* p. 337, pl. xliii. fig. 3; also a fragment labelled by Agassiz. *Enniskillen Coll.*

P. 6231. Fragmentary specimen. *Purchased.*

P. 2535. Type specimen of *C. limaformis*, J. W. Davis, *loc. cit.* p. 339, pl. xliv. fig. 5. This is a much broken spine, and so far as its characters are distinguishable cannot be separated from *C. brevis*; the published figure is misleading. *Enniskillen Coll.*

Ctenacanthus heterogyrus, M'Coy.

1843. *Ctenacanthus heterogyrus*, L. Agassiz, Poiss. Foss. vol. iii. p. 177 (name only).
1855. *Ctenacanthus heterogyrus*, F. M'Coy, Brit. Palæoz. Foss. p. 625, pl. iii. I. fig. 32.
(?) 1878. *Ctenacanthus heterogyrus*, L. G. de Koninck, Faune Calc. Carb. Belg. pt. i. p. 66, pl. vii. fig. 3.
1883. *Ctenacanthus heterogyrus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 336, pl. xliv. figs. 1–3.

Type. Woodwardian Museum, Cambridge.

Form. & Loc. Lower Carboniferous Limestone: Armagh, and (?) Tournai, Belgium.

P. 2526–7. Two specimens, much worn at the distal extremity, figured by J. W. Davis, *loc. cit.* *Enniskillen Coll.*

P. 2528, P. 2671. Seven imperfect specimens, similarly worn distally; also a much abraded spine, probably of the same species. *Enniskillen Coll.*

P. 2228. Spine extremely worn distally. *Egerton Coll.*

28928–29. Two fragmentary spines. *Purchased*, 1854.

The following is an indeterminable crushed and broken spine slightly smaller than most examples of *C. heterogyrus*:—

P. 2530. Type specimen of *Ctenacanthus dubius*, J. W. Davis, *loc. cit.* p. 340, pl. xliv. fig. 7; Lower Carboniferous Limestone, Armagh. *Enniskillen Coll.*

Ctenacanthus sulcatus (Agassiz).

1837. *Onchus sulcatus*, L. Agassiz, Poiss. Foss. vol. iii. p. 8, pl. i. fig. 6.
1883. *Ctenacanthus sulcatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 343, pl. xlv. fig. 3.

Type. Bristol Museum.

Form. & Loc. Lower Carboniferous Limestone: Gloucestershire, Shropshire, and (?) Armagh, Ireland.

P. 228. Imperfect exserted portion of spine; Oreton, Shropshire. *Weaver-Jones Coll.*

P. 2670. Smaller, more slender spine, similarly marked; Armagh. *Enniskillen Coll.*

P. 2871. Very small spine, similarly marked and distally worn; Armagh. *Enniskillen Coll.*

Ctenacanthus (?) lævis, Davis.

1883. *Ctenacanthus lævis*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 341, pl. xlv. fig. 1.

Type. Bristol Museum.
This species may pertain to *Acondylacanthus*.
Form. & Loc. Lower Carboniferous Limestone : Armagh.

P. 2531. Type specimen. *Enniskillen Coll.*

P. 2532–3, P. 2673. Three imperfect spines. *Enniskillen Coll.*

39166. Much crushed imperfect spine. *Bowerbank Coll.*

Ctenacanthus (?) pustulatus, Davis.

1883. *Ctenacanthus pustulatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 344, pl. xlv. fig. 2.

Type. British Museum.
This species may pertain to *Asteroptychius*.
Form. & Loc. Lower Carboniferous Limestone: Armagh.

P. 2529. Type specimen. *Enniskillen Coll.*

The following species have also been described, but there are no examples in the Collection :—

Ctenacanthus angulatus, Newberry & Worthen, Pal. Illinois, vol. ii. (1866), p. 118, pl. xii. fig. 4.—Chester Limestone ; Illinois.

Ctenacanthus angustus, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 181.—Berea Grit (Lower Carboniferous) ; Berea, Ohio.

Ctenacanthus burlingtonensis, St. John & Worthen, Pal. Illinois, vol. vi. (1875), p. 426, pl. xv. figs. 6, 7.—Upper Burlington Limestone ; Illinois and Iowa. [? *Acondylacanthus.*]

Ctenacanthus buttersi, St. John & Worthen, *op. cit.* vol. vii. (1883), p. 240, pl. xxii. fig. 2.—Lower Coal-Measures ; Illinois.

Ctenacanthus cannaliratus, St. John & Worthen, *op. cit.* vol. vii. p. 239, pl. xxi. fig. 3.—Chester Limestone ; Illinois.

Ctenacanthus clarki, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 168, pl. xxvi. figs. 2, 3.—Cleveland Shale (Lower Carboniferous) ; Berea, Ohio. [Columbia College, New York.]

Ctenacanthus compressus, J. S. Newberry, Ann. New York Acad. Sci. vol. i. (1878), p. 191, and Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 168, pl. xxiii. fig. 4.—Cleveland Shale (Lower Carboniferous); Lorain Co., Ohio. [Columbia College, New York.]

Ctenacanthus coxianus, St. John & Worthen, *op. cit.* vol. vii. p. 233, pl. xxi. fig. 1.—Keokuk Limestone; Iowa.

Ctenacanthus crenatus, F. M'Coy, Brit. Palæoz. Foss. 1855, p. 624, pl. iii. I. fig. 31: *Ctenacanthus crenulatus*, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 177 (name only); J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. (1883), p. 345, pl. xlv. fig. 6.—Lower Carboniferous Limestone; Armagh, Ireland. [Woodwardian Museum, Cambridge.]

Ctenacanthus cylindricus, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 202, pl. xxvi. fig. 1.—Keokuk Limestone Shale; Casey Co., Kentucky.

Ctenacanthus deflexus, St. John & Worthen, *op. cit.* vol. vii. p. 234, pl. xxii. fig. 1.—St. Louis Limestone; Illinois.

Ctenacanthus elegans, M. Tuomey, Geol. Alabama (1858), p. 38, woodcut fig. A.—Lower Carboniferous: North Alabama.

Ctenacanthus excavatus, St. John & Worthen, *op. cit.* vol. vi. p. 428, pl. xv. figs. 4, 5.—Keokuk Limestone; Iowa and Missouri.

Ctenacanthus formosus, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 328, pl. xxxvi. fig. 2, and *ibid.* vol. ii. pt. ii. (1875), p. 53, pl. lix. fig. 1.—Waverly Group; Ohio and Kentucky. [Columbia College, New York.]

Ctenacanthus furcicarinatus, J. S. Newberry, *op. cit.* vol. ii. pt. ii. p. 54, pl. lix. fig. 2.—Waverly Group; Kentucky. [Associated with teeth of *Orodus variabilis*.]

Ctenacanthus gemmatus, St. John & Worthen, *op. cit.* vol. vi. p. 429, pl. xv. figs. 9, 10.—St. Louis Limestone; Illinois.

Ctenacanthus gradocostus, St. John & Worthen, *op. cit.* vol. vi. p. 425, pl. xv. figs. 2, 3.—Upper Burlington Limestone; Iowa and Illinois.

Ctenacanthus harrisoni, St. John & Worthen, *op. cit.* vol. vii. p. 236, pl. xxiii. fig. 1.—St. Louis Limestone; Illinois.

Ctenacanthus keokuk, St. John & Worthen, *op. cit.* vol. vi. p. 427, pl. xv. fig. 8.—Keokuk Limestone; Illinois, Iowa, and Missouri.

Ctenacanthus littoni, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 201, pl. xxv. fig. 3.—St. Louis Limestone; St. Louis, Missouri.

Ctenacanthus marshi, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. p. 326, pl. xxxvi. fig. 3.—Coal-Measures; Ohio.

Ctenacanthus mayi, Newberry & Worthen, Pal. Illinois, vol. iv. (1870), p. 372, pl. ii. fig. 2.—Lower Carboniferous Limestone; Iowa.

Ctenacanthus pellensis, St. John & Worthen, Pal. Illinois, vol. vii. p. 237, pl. xxi. fig. 2.—St. Louis Limestone; Iowa.

Ctenacanthus plicatus, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. (1883), p. 342, pl. xlv. fig. 4: *Onchus plicatus*, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 177 (name only).—Lower Carboniferous Limestone; Armagh. [Mus. Geol. Soc., London.]

Ctenacanthus pugiunculus, St. John & Worthen, *op. cit.* vol. vi. p. 430, pl. xxi. fig. 9.—St. Louis Limestone; Missouri.

Ctenacanthus randalli, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 105.—Chemung Group (Olean Conglomerate); Warren, Pa.

Ctenacanthus rectus, J. W. Davis, *loc. cit.* vol. i. p. 345, pl. xlv. fig. 5: *Onchus rectus*, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 177 (name only).—Lower Carboniferous Limestone; Armagh. [Mus. Geol. Soc. London.]

Ctenacanthus sculptus, St. John & Worthen, *op. cit.* vol. vi. p. 421, pl. xiv. fig. 1.—Kinderhook Limestone; Iowa.

Ctenacanthus similis, St. John & Worthen, *op. cit.* vol. vi. p. 431, pl. xv. fig. 11.—Chester Limestone; Illinois.

Ctenacanthus speciosus, St. John & Worthen, *op. cit.* vol. vi. p. 424, pl. xiv. figs. 3, 4.—Kinderhook Limestone; Iowa.

Ctenacanthus spectabilis, St. John & Worthen, *op. cit.* vol. vi. p. 420, pl. xv. fig. 1.—Kinderhook Limestone; Iowa.

Ctenacanthus triangularis, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. (1873), pt. i. p. 329, pl. xxxvi. fig. 1.—Waverly Group; Pennsylvania. (?) Carboniferous Limestone; Mjatschkowa, Moscow (H. Trautschold, Nouv. Mém. Soc. Imp. Nat. Moscou, vol. xiv. 1879, p. 61, pl. vi. fig. 15).

Ctenacanthus varians, St. John & Worthen, *op. cit.* vol. vi. p. 422, pl. xiv. fig. 2.—Kinderhook Limestone; Iowa.

Ctenacanthus vetustus, J. S. Newberry, *op. cit.* vol. i. pt. i. p. 326, pl. xxxv. fig. 3.—Huron Shale; Ohio. [Columbia College, New York.]

Ctenacanthus wrighti, J. S. Newberry, Thirty-fifth Rep. New York State Mus. (1884), p. 206, pl. xvi. figs. 12–14, and Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 66, pl. xxvi. fig. 4.—Hamilton Group (Upper Devonian); Kashong Creek, New York. [Columbia College.]

The so-called *Ctenacanthus*? *fallax*, J. Leidy, MS. (figured in the Trans. Amer. Phil. Soc. vol. xi. 1857, pl. v. fig. 30), from the American Carboniferous Limestone, is founded upon an indeterminable fossil in the Museum of the Academy of Sciences, Philadelphia.

Spines differing only from *Ctenacanthus* in minor points have been named as follows :—

Anaclitacanthus, St. John & Worthen (Pal. Illinois, vol. vi. 1875, p. 442), with the single species, *A. semicostatus*, St. John & Worthen, *ibid.* p. 443, pl. xvi. fig. 14.—Upper Burlington Limestone; Iowa.

Eunemacanthus, St. John & Worthen (*op. cit.* vol. vii. 1883, p. 246), with the single species, *E. costatus*, St. John & Worthen, *ibid.* p. 246, pl. xxiii. fig. 2, previously named *Ctenacanthus*? *costatus*, Newberry & Worthen, Pal. Illinois, vol. ii. 1866, p. 120, pl. xii. fig. 5.—St. Louis Limestone; Illinois and Missouri.

Genus **HOMACANTHUS**, Agassiz.

[Poiss. Foss. Vieux Grès Rouge, 1845, p. 113.]

Dorsal fin-spines of small size, slender, more or less arched, much laterally compressed, and gradually tapering distally; sides of exserted portion ornamented with few, large, smooth, widely-spaced longitudinal ridges; a similar ridge also forming a large anterior keel; posterior face with a double series of large, downwardly-curved denticles.

Homacanthus arcuatus, Agassiz.

1844. *Hybodus gracilis*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. p. 827.

1845. *Homacanthus arcuatus*, L. Agassiz, *op. cit.* p. 113, pl. xxxiii. figs. 1–3.

1860. *Homacanthus gracilis*, E. von Eichwald, Leth. Rossica, vol. i. p. 1600, pl. lv. fig. 9.

The type species.

Form. & Loc. Devonian; N.W. Russia.

P. 2253. Fragment of spine. *Egerton Coll.*

Homacanthus microdus, M'Coy.

1848. *Homacanthus microdus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 115.

1855. *Homacanthus microdus*, F. M'Coy, Brit. Palæoz. Foss. p. 633, pl. iii. K. fig. 19.

1883. *Homacanthus microdus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 361, pl. xlviii. figs. 7–9.

Type. Woodwardian Museum, Cambridge.
Form. & Loc. Lower Carboniferous Limestone; Armagh, Ireland.

P. 2516–18. Three spines, described and figured by J. W. Davis, *loc. cit.* *Enniskillen Coll.*

P. 2515. Ten specimens, the majority very imperfect. *Enniskillen Coll.*

The following specimens are somewhat smaller than *H. microdus*, with more numerous longitudinal ridges than the foregoing:—

42258. Spine, imperfect distally and proximally; Carboniferous Limestone, Shropshire. *Baugh Coll.*

P. 2247. Distal portion of spine, gently arched, with traces of well-developed posterior denticles, labelled *Onchus subulatus* in Agassiz's handwriting, and doubtless intended to be the type specimen of that species (named in Poiss. Foss. vol. iii. 1843, p. 177); Coal-Measures, Ruabon, Denbighshire. *Egerton Coll.*

The following species has also been described:—

Homacanthus macrodus, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 115, and Brit. Palæoz. Foss. (1855), p. 632, pl. iii. K. fig. 20; J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. (1883), p. 362.—Lower Carboniferous Limestone; Armagh. [Woodwardian Museum, Cambridge.]

Two spines from the St. Louis Limestone of Missouri and Illinois have also been described under the names of *Homacanthus gibbosus*, Newberry & Worthen (Pal. Illinois, vol. ii. 1866, p. 113, pl. xii. fig. 1), and *H.* ? *rectus*, Newberry & Worthen (*ibid.* p. 115, pl. xii. fig. 6). The former is now made the type of the genus *Amacanthus*, St. John & Worthen (Pal. Illinois, vol. vi. 1875, p. 464, pl. xxii. fig. 6), and the latter that of *Marracanthus*, St. John & Worthen (*ibid.* pp. 465, 466, pl. xxii. figs. 7–9).

The spine named *Homacanthus gracilis*, J. F. Whiteaves (Trans. Roy. Soc. Canada, vol. vi. sect. iv. 1888, p. 96, pl. x. fig. 4), is also doubtfully determined, and may belong to an Acanthodian fish resembling *Climatius*. The type specimen was obtained from the Lower Devonian of Campbellton, New Brunswick, and is preserved in the Geological Survey Museum, Ottawa.

Closely related to *Homacanthus* is the spine described as follows :—

Hoplonchus, J. W. Davis (Quart. Journ. Geol. Soc. vol. xxxii. (1876), p. 336), with the type species, *H. elegans*, J. W. Davis, *ibid.* vol. xxxv. (1879), p. 183, pl. x. figs. 12–14.—Lower Coal-Measures; Yorkshire. [J. W. Davis Collection, Halifax.]

A second species is named *H. parvulus*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 169, pl. xxv. fig. 5. This spine was previously described as *Ctenacanthus parvulus* (J. S. Newberry, Rep. U.S. Geol. Surv. Ohio, vol. ii. pt. ii. 1875, p. 55, pl. lix. fig. 3), and was obtained from the Cleveland Shale (Lower Carboniferous) of Ohio.

Genus **ACONDYLACANTHUS,** St. John & Worthen.

[Pal. Illinois, vol. vi. 1875, p. 432.]

Dorsal fin-spines slender, elongated, laterally compressed and gradually tapering; sides of exserted portion ornamented with longitudinal ridges, usually smooth, rarely crenulated or denticulated; posterior face concave, with a series of small denticles upon each margin, and sometimes with a median keel.

As proved by specimens in the Collection (*e. g.* no. P. 2536 *a*) these slender spines have a short base of insertion, resembling that of *Ctenacanthus*.

In their latest interpretation of this "genus," St. John & Worthen include in it *Ctenacanthus*-shaped spines with smooth ridges, while long slender spines with denticulated ridges are placed in *Ctenacanthus* proper. We prefer, however, to follow Davis in regarding the form of the spine as the character of foremost importance.

Acondylacanthus attenuatus, Davis.

1883. *Acondylacanthus attenuatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 352, pl. xlvi. fig. 3.

Type. Woodwardian Museum, Cambridge.

Form. & Loc. Lower Carboniferous Limestone: Armagh, Ireland.

P. 2672, P. 2674–5. Three imperfect distal portions of spines. *Enniskillen Coll.*

Acondylacanthus colei, Davis.

[Plate I. fig. 2.]

1883. *Acondylacanthus colei*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 347, pl. xlv. fig. 7, pl. xlvi. fig. 1.

Type. British Museum.
Form. & Loc. Lower Carboniferous Limestone; Armagh.

P. 2538. Type specimen, figured by Davis, *loc. cit.* pl. xlv. fig. 7. *Enniskillen Coll.*

P. 2536. Ten more fragmentary spines. *Enniskillen Coll.*

P. 2536 a. Fragment of crushed spine exhibiting the line of demarcation between the exserted and inserted portions. *Enniskillen Coll.*

P. 4199. Portion of spine showing well the median posterior keel. *Enniskillen Coll.*

39167. Portion of crushed spine, with lateral ridges partly nodose; a transverse section is shown in Pl. I. fig. 2. *Bowerbank Coll.*

Acondylacanthus tenuistriatus, Davis.

1883. *Acondylacanthus tenuistriatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 350, pl. xlv. fig. 8.

Type. British Museum.
Form. & Loc. Lower Carboniferous Limestone: Armagh.

P. 2890. Type specimen. *Enniskillen Coll.*

P. 2890 a. More imperfect portion of spine. *Enniskillen Coll.*

Acondylacanthus distans (M'Coy).

1848. *Ctenacanthus distans*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 116.
1855. *Ctenacanthus distans*, F. M'Coy, Brit. Palæoz. Foss. p. 625, pl. iii. K. fig. 15.
1883. *Acondylacanthus distans*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 349, pl. xlvi. fig. 5.

Type. Woodwardian Museum, Cambridge.
Form. & Loc. Lower Carboniferous Limestone: Armagh. Carboniferous Limestone; Denbighshire.

39917. Imperfect spine, 0·23 in length; Denbighshire.
Purchased, 1866.

The following specimen may also be referred to *Acondylacanthus*:—

49652. Portion of an extremely compressed slender spine, with fine, smooth, superficial longitudinal ridges; Upper Carboniferous Limestone, Richmond, Yorkshire.
Purchased, 1878.

The following species have also been ascribed to this genus:—

Acondylacanthus æquicostatus, St. John & Worthen, Pal. Illinois, vol. vi. (1875), p. 434, pl. xvi. figs. 12, 13.—Keokuk Limestone; Illinois.

Acondylacanthus gracilis, St. John & Worthen, *op. cit.* vol. vi. p. 433, pl. xvi. figs. 8–11.—Kinderhook Limestone; Iowa. [The type species.]

Acondylacanthus jenkinsoni, St. John & Worthen, *op. cit.* vol. vi. p. 433; J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 351, pl. xlvi. fig. 2: *Leptacanthus jenkinsoni*, F. M'Coy, Brit. Palæoz. Foss. 1855, p. 633, pl. iii. G. figs. 14–16.—Carboniferous Limestone; Lowick, Northumberland. [Woodwardian Museum, Cambridge.]

Acondylacanthus junceus, St. John & Worthen, *op. cit.* vol. vi. p. 433; J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 350, pl. xlvi. fig. 6: *Leptacanthus junceus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 122, and Brit. Palæoz. Foss. (1855), p. 633, pl. iii. G. fig. 13.—Carboniferous Limestone; Derbyshire. [Woodwardian Museum.]

Acondylacanthus occidentalis, St. John & Worthen, *op. cit.* vol. vi. p. 433; J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 206, pl. xxv. fig. 6: *Leptacanthus? occidentalis*, Newberry & Worthen, Pal. Illinois, vol. ii. (1866), p. 116, pl. xii. fig. 2: *Ctenacanthus gracillimus*, Newberry & Worthen, *ibid.* p. 126, pl. xiii. fig. 3; St. John & Worthen, *op. cit.* vol. vii. (1883), p. 238, pl. xxiv. fig. 1.—St. Louis Limestone; Missouri, Illinois, and Michigan.

Acondylacanthus rectus, St. John & Worthen, *op. cit.* vol. vii. p. 241, pl. xxvi. fig. 2.—Upper Coal-Measures; Illinois.

Acondylacanthus remotus: *Leptacanthus remotus*, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1601, pl. lvi. fig. 4.—Carboniferous Limestone; Kalouga, on River Protva, Russia. [University of St. Petersburg.]

Acondylacanthus tenuistriatus, St. John & Worthen (*non* Davis), *op. cit.* vol. vi. p. 433 : *Cladodus tenuistriatus*, H. Romanowsky, Bull. Soc. Imp. Nat. Moscou, 1864, pt. ii. p. 167, pl. iv. fig. 33.—Carboniferous Limestone : Govt. of Toula.

Acondylacanthus tuberculatus, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. (1883), p. 348, pl. xlvi. fig. 4.—Lower Carboniferous Limestone : Armagh. [*Olim* Enniskillen Collection ; see Introduction.]

Doubtful spines are also named *Acondylacanthus? mudgianus*, St. John & Worthen (*op. cit.* vol. vii. p. 244, pl. xxiv. fig. 3), from the Upper Coal-Measures of Kansas : *A. nuperus*, St. John & Worthen (*op. cit.* vol. vii. p. 242, pl. xxvi. fig. 3), from the Upper Coal-Measures of Illinois ; and *A.? xiphias*, St. John & Worthen (*op. cit.* vol. vii. p. 244, pl. xxvi. fig. 1), from the Keokuk Limestone of Iowa.

Genus **ASTEROPTYCHIUS**, M'Coy (*ex* Agassiz, MS.).

[Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 118.]

Dorsal fin-spines slender, much laterally compressed, gradually tapering distally ; sides of exserted portion ornamented with few thread-like, longitudinal ridges, with broad striated interspaces, in which are scattered smooth tubercles ; posterior face concave, each margin having a series of large denticles in part directed upwards.

Asteroptychius ornatus, M'Coy (*ex* Agassiz, MS.).

1843. *Asteroptychius ornatus*, L. Agassiz, Poiss. Foss. vol. iii. p. 176 (name only).

(?) 1843. *Asteroptychius portlockii*, L. Agassiz, *ibid.* p. 176 (name only).

1848. *Asteroptychius semiornatus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 118. [Woodwardian Museum, Cambridge.]

1855. *Asteroptychius ornatus*, F. M'Coy, Brit. Palæoz. Foss. p. 615, pl. iii. K. figs. 23, 24.

1855. *Asteroptychius semiornatus*, F. M'Coy, *ibid.* p. 616, pl. iii. K. fig. 22.

1883. *Asteroptychius ornatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 353, pl. xlvi. figs. 7–9.

Type. Woodwardian Museum, Cambridge.

The type species.

Form. & Loc. Lower Carboniferous Limestone ; Armagh, Ireland .

P. 2541–2. Twelve imperfect specimens. *Enniskillen Coll.*

The following species have also been described, but there are no examples in the Collection :—

Asteroptychius bellulus, St. John & Worthen, Pal. Illinois, vol. vi. (1875), p. 439, pl. xvi. fig. 7.—Coal-Measures; Illinois and Iowa.

Asteroptychius elegans, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 176, pl. xxv. fig. 4.—Waverly Group (Lower Carboniferous); Michigan. [Columbia College, New York.]

Asteroptychius sancti-ludovici, St. John & Worthen, *op. cit.* vol. vi. p. 437, pl. xvi. figs. 3, 4.—St. Louis Limestone; Illinois and Missouri.

Asteroptychius triangularis, Newberry & Worthen, Pal. Illinois, vol. iv. (1870), p. 370, pl. ii. fig. 4.—Burlington Limestone; Illinois.

Four doubtful, fragmentary spines are also named *Asteroptychius keokuk*, St. John & Worthen (*op. cit.* vol. vi. p. 436, pl. xvi. fig. 2), from the Keokuk Limestone of Illinois; *A. tenellus*, St. John & Worthen (*op. cit.* vol. vii. p. 248, pl. xxi. fig. 4), from the Upper Coal-Measures of Kansas; *A.? tenuis*, St. John & Worthen (*op. cit.* vol. vi. p. 438, pl. xvi. figs. 5, 6), from the Chester Limestone of Illinois; and *A. vetustus*, St. John & Worthen (*op. cit.* vol. vi. p. 435, pl. xvi. fig. 1), from the Kinderhook Limestone of Iowa.

Genus **COSMACANTHUS**, Agassiz.

[Poiss. Foss. Vieux Grès Rouge, 1845, p. 120.]

Syn. *Geisacanthus*, St. John & Worthen, Pal. Illinois, vol. vi. (1875), p. 440.

Dorsal fin-spines of small size, slender, more or less laterally compressed and very slightly arched; sides of exserted portion ornamented with longitudinal series of ganoine-coated tubercles, and the anterior margin often keeled; posterior face flat or concave, without lateral denticles, but sometimes with a median keel.

The type species of this genus (*C. malcolmsoni*) is regarded by Pander[1] as founded upon a fragment of Placoderm armour; and if this re-determination prove correct, the Carboniferous Ichthyodorulites recorded below must be named *Geisacanthus*.

[1] C. H. Pander, Placoderm. devon. Syst. 1857, p. 18.

Cosmacanthus marginalis, Davis.

1883. *Cosmacanthus marginalis*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 355, pl. xlviii. fig. 3.

Type. British Museum.
Form. & Loc. Lower Carboniferous Limestone: Armagh, Ireland.

P. 2894. Type specimen. *Enniskillen Coll.*

P. 2894 a. More complete but much abraded and broken spine. *Enniskillen Coll.*

Cosmacanthus carinatus, Davis.

1883. *Cosmacanthus carinatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 356, pl. xlviii. fig. 4.

Type. British Museum.
Form. & Loc. Lower Carboniferous Limestone: Armagh.

P. 2893. Type specimen. *Enniskillen Coll.*

Cosmacanthus priscus (M'Coy).

1843. *Leptacanthus priscus*, L. Agassiz, Poiss. Foss. vol. iii. p. 176 (name only).
1848. *Nemacanthus priscus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 120.
1883. *Cosmacanthus priscus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 358, pl. xlviii. figs. 1, 2.

Type. Geological Society of London.
Form. & Loc. Lower Carboniferous Limestone: Armagh.

P. 2237. Fragment of spine. *Egerton Coll.*

The following species have also been described, but there are no examples in the Collection :—

Cosmacanthus bullatus: *Geisacanthus bullatus*, St. John & Worthen, Pal. Illinois, vol. vi. (1875), p. 441, pl. xvii. figs. 3, 4.—Lower Chester Limestone; Illinois.

Cosmacanthus carbonarius, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 119; J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. (1883), p. 357.—Lower Carboniferous Limestone; Armagh.

Cosmacanthus malcolmsoni, L. Agassiz, Poiss. Foss. Vieux Grès Rouge (1845), p. 121, pl. xxxiii. fig. 28.—Upper Old Red Sandstone; Scat Craig, Elgin, Scotland. [The type species; collection of James Powrie, Esq., Reswallie.]

Cosmacanthus stellatus: *Geisacanthus stellatus*, St. John & Worthen, *tom. cit.* p. 440, pl. xxi. fig. 10.—Upper St. Louis Limestone; Missouri. [The type species of *Geisacanthus*.]

Four other Lower Carboniferous genera of tuberculated spines, with a deep base of insertion, and probably for the most part bilaterally symmetrical, are also recognized, as follows:—

Bythiacanthus, St. John & Worthen (Pal. Illinois, vol. vi. 1875, p. 444), comprising *B. van-hornei*, St. John & Worthen (*ibid.* p. 445, pl. xvii. fig. 1), from the Upper St. Louis Limestone of Illinois; and the so-called *Asteracanthus siderius*, J. Leidy, Proc. Acad. Nat. Sci. Philad. 1870, p. 13, and Ext. Vert. Fauna W. Territ. (Rep. U.S. Geol. Surv. Territ. vol. i. 1873), p. 313, pl. xxxii. fig. 59, probably from the St. Louis Limestone of Tennessee. [The second fossil, now in the Museum of the Academy of Sciences, Philadelphia, may be a broken piece of the abraded border of an *Oracanthus*-shaped spine.]

Glymmatacanthus, St. John & Worthen (*op. cit.* vol. vi. p. 446), comprising *G. irishi*, St. John & Worthen (*ibid.* p. 447, pl. xvii. fig. 2), from the Upper Kinderhook Limestone of Iowa; *G. petrodoides*, St. John & Worthen (*op. cit.* vol. vii. 1883, p. 250, pl. xxv. fig. 2), from the Chester Limestone of Illinois; and *G. rudis*, St. John & Worthen (*op. cit.* vol. vii. p. 249, pl. xxv. fig. 1), from the Keokuk Limestone of Iowa.

Thaumatacanthus, W. Waagen, Salt-Range Fossils (Palæont. Indica, ser. 13), vol. i. (1880), p. 78, with the single species, *T. blanfordi*, Waagen (*ibid.* p. 79, pl. viii. fig. 1), from the Upper Productus Limestone of Kiri, in the Salt Range, Punjab, India. [Indian Museum, Calcutta.]

Chalazacanthus, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. (1883), p. 370, with the single species *C. verrucosus*, Davis (*ibid.* p. 371, pl. xlviii. fig. 13), from the Lower Carboniferous Limestone of Bristol. [Bristol Museum.]

Genus **LISPACANTHUS,** Davis.

[Trans. Roy. Dublin Soc. [2] vol. i. 1883, p. 359.]

Dorsal fin-spine of medium size, slender, laterally compressed, and gradually tapering; sides of exserted portion apparently smooth; posterior face with a median longitudinal keel, but no denticles; base-line of exserted portion very oblique.

Lispacanthus retrogradus, Davis.

1883. *Lispacanthus retrogradus*, J. W. Davis, *tom. cit.* p. 359, pl. xlviii. fig. 5.

Type. British Museum.
The type species.
Form. & Loc. Lower Carboniferous Limestone: Armagh.

P. 2544. Type specimen. The smoothness of the exserted portion may be due to abrasion, but at present there is no decided evidence of this. *Enniskillen Coll.*

The following spine is also doubtfully placed here :—

Lispacanthus gracilis, J. W. Davis, *tom. cit.* p. 359, pl. xlviii. fig. 6.—Carboniferous Limestone; Kendal Fells, Westmoreland. [Mus. Geol. Soc. London.]

Genus **LEPRACANTHUS,** Owen.

[Geol. Mag. vol. vi. 1869, p. 481.]

Dorsal fin-spines of small size, slender, much laterally compressed, and gently arched; sides of exserted portion ornamented with longitudinal series of large ganoine-coated tubercles, almost pear-shaped or comma-shaped and connected in the distal portion of the spine, but becoming obliquely oval and well separated proximally; anterior margin keeled; posterior face with few large slender denticles.

Lepracanthus colei, Owen.

[Plate I. fig. 1.]

1843. *Lepracanthus colei*, Sir P. Egerton, in Agassiz, Poiss. Foss. vol. iii. p. 177 (name only).
1869. *Lepracanthus colei*, R. Owen, Geol. Mag. vol. vi. p. 481, woodc.
1876. *Lepracanthus colei*, J. W. Davis, Quart. Journ. Geol. Soc. vol. xxxii. p. 335.

Type. British Museum.
The type species.
Form. & Loc. Coal-Measures: N. Wales, Yorkshire, and Lanarkshire.

P. 2861, P. 615. Type specimen and counterpart, shown somewhat enlarged and restored in the accompanying woodcut (fig. 9); Ruabon, Denbighshire. The posterior denticles are well preserved. *Enniskillen & Egerton Colls.*

P. 2233. Spine and fragment, the former exhibiting the lateral ornament and anterior keel; Lower Coal-Measures, Lowmoor, Yorkshire. The spine is shown, of natural size, in

Fig. 9.

Lepracanthus colei, Owen. Coal-Measures, Ruabon. [P. 2861.]

Plate I. fig. 1, and a portion of the ornament is enlarged four times in fig. 1 *a*. *Egerton Coll.*

P. 2902. More arched spine; Lowmoor. *Enniskillen Coll.*

Genus **NEMACANTHUS**, Agassiz.

[Poiss. Foss. vol. iii. 1837, p. 25.]

Syn. *Desmacanthus*, F. A. Quenstedt, Der Jura, 1858, p. 34.

Dorsal fin-spines of small or moderate size, much laterally compressed, nearly straight; sides of exserted portion marked with fine longitudinal striæ, thus not sharply separated from the inserted portion, though exhibiting large, rounded, ganoine-coated tubercles, in longitudinal series, covering a variable extent; anterior margin prominently keeled; posterior face with a row of small pointed denticles upon each edge.

The Rhætic spines assigned to this genus are not improbably referable to the dorsal fins of the fish of which the teeth are known as *Hybodus minor*[1].

Nemacanthus monilifer, Agassiz.

1837. *Nemacanthus monilifer*, L. Agassiz, Poiss. Foss. vol. iii. p. 26, pl. vii. figs. 10–15.
1837. *Nemacanthus filifer*, L. Agassiz, *ibid.* p. 26, pl. vii. fig. 9. [Bristol Museum.]
(?) 1844. *Nemacanthus monilifer* and *N. filifer*, Meyer & Plieninger, Beitr. Pal. Württembergs, p. 108, pl. xii. figs. 65, 66.
1858. *Desmacanthus cloacinus*, F. A. Quenstedt, Der Jura, p. 34, pl. ii. fig. 13. [Type of *Desmacanthus*, Tübingen Museum.]
1874. *Nemacanthus monilifer*, K. Martin, Zeitschr. deutsch. geol. Ges. vol. xxvi. p. 820.
1881. *Nemacanthus monilifer*, J. W. Davis, Quart. Journ. Geol. Soc. vol. xxxvii. p. 418.
1881. *Nemacanthus filifer*, J. W. Davis, *ibid.* p. 418.

Type. British Museum.
The type species.
Form. & Loc. Rhætic: Gloucestershire, Somersetshire, Devonshire, and Leicestershire; Würtemberg.

23153 b. Two fragments; Aust Cliff, near Bristol. *Purchased*, 1849.

23812. Five portions of spines; Aust Cliff. *Purchased*, 1849.

24840. Bone-bed with fragments of three spines; Aust Cliff. *Purchased*, 1850.

43852. Four fragments; Aust Cliff. *Purchased*, 1872.

44835. Portion of large spine; Aust Cliff. *Presented by Benjamin Bright, Esq.*, 1873.

46830. Small spine; Aust Cliff. *By transfer*, 1875.

P. 2217. Six portions of spines, two being associated; Aust Cliff. *Egerton Coll.*

P. 2852. Two fragments; Aust Cliff. *Enniskillen Coll.*

P. 2854. Small spine; Somersetshire. *Enniskillen Coll.*

P. 2853. Nearly complete small spine; Axminster. *Enniskillen Coll.*

[1] A. S. Woodward, Trans. Leicester Lit. & Phil. Soc. n. s. pt. xi. (1889), p. 18.

Nemacanthus brevis, Phillips.

1843. *Nemacanthus brevispinus,* L. Agassiz, Poiss. Foss. vol. iii. p. 177 (name only).

1871. *Nemacanthus brevis,* J. Phillips, Geol. Oxford, p. 178, diagr. xxxviii. figs. 3–5.

1890. *Nemacanthus brevis,* A. S. Woodward, Proc. Geol. Assoc. vol. xi. p. 289, pl. iii. fig. 1.

Type. Oxford Museum.

Form. & Loc. Bathonian (Stonesfield Slate): Stonesfield, Oxfordshire.

P. 2218. Two specimens, one figured by the present writer, *loc. cit.* pl. iii. fig. 1. *Egerton Coll.*

P. 2851. Two specimens. *Enniskillen Coll.*

The following species have also been determined:—

Nemacanthus granulosus, Münster, in L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 177 (name only); (?) F. von Alberti, Ueberblick über die Trias (1864), p. 208, pl. vii. fig. 9.—Muschelkalk; Laineck, Bavaria.

Nemacanthus minor, J. W. Davis, Quart. Journ. Geol. Soc. vol. xxxvii. (1881), p. 419, pl. xxii. fig. 5.—Rhætic; Wainlode Cliff, Gloucestershire. [Mus. Geol. Soc. London.]

Nemacanthus sentionis, Münster, in Agassiz, Poiss. Foss. vol. iii. (1843), p. 177 (name only). Quoted as *N. senticosus* by C. G. Giebel, Fauna der Vorwelt, vol. i. (1848), Fische, p. 304.—Muschelkalk; Laineck, Bavaria.

Nemacanthus tuberculatus, F. Bassani, Atti Soc. Ital. Sci. Nat. vol. xxix. (1886), p. 30.—Upper Trias; Besano, Lombardy.

The following spine may also be referable to this group of Ichthyodorulites:—

Psilacanthus aalensis, F. A. Quenstedt, Der Jura (1858), p. 347, pl. xlvii. fig. 20.—Brown Jura β; Aalen, Würtemberg. [Tübingen University Museum.]

II. Slender elongated spines, bilaterally symmetrical, with the internal cavity only open at the extremity of the base, and little or no smooth inserted portion.

Genus **GNATHACANTHUS,** Davis.

[Trans. Roy. Dublin Soc. [2] vol. i. 1883, p. 363.]

Spine laterally compressed, with one margin acute, the other flattened; sides ornamented with longitudinal ridges, smooth or tuberculated; acute margin with a single series of large denticles, flattened margin with a double series of smaller denticles.

The base of the spine is unknown, and *Gnathacanthus* is thus only provisionally placed in this group of Ichthyodorulites.

Gnathacanthus triangularis, Davis.

1883. *Gnathacanthus triangularis*, J. W. Davis, *tom. cit.* p. 363, pl. xlviii. fig. 11.

Type. British Museum.
The type species.
Form. & Loc. Lower Carboniferous Limestone: Armagh.

P. 2891. Type specimen. *Enniskillen Coll.*

Gnathacanthus striatus, Davis.

1883. *Gnathacanthus striatus*, J. W. Davis, *tom. cit.* p. 364, pl. xlviii. fig. 12.

Type. British Museum.
Form. & Loc. Lower Carboniferous Limestone: Armagh.

P. 2892. Type specimen. *Enniskillen Coll.*

P. 2892 a. Fragment. *Enniskillen Coll.*

Genus **APATEACANTHUS,** nov.

Spine elongated, slender, very gradually tapering, extremely compressed laterally; sides ornamented with irregular series of tuberculations; posterior border with one (? or two) close series of acute, hook-shaped, downwardly-pointing denticles.

Apateacanthus vetustus (Clarke).

1885. *Pristacanthus vetustus*, J. M. Clarke, Bull. U.S. Geol. Surv. no. 16, p. 42, pl. i. fig. 7.

Type. National Museum, Washington.

The type species. Known only by the type specimen, which is very suggestive of a Chimæroid dorsal fin-spine, and certainly pertains to a hitherto unrecognized genus, as already suggested by J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889, p. 61).

Form. & Loc. Upper Devonian (Naples Shales): Yates Co., New York.

Not represented in the Collection.

Genus **PRISTACANTHUS,** Agassiz.

[Poiss. Foss. vol. iii. 1837, p. 35.]

Spine very long, slender, and gradually tapering, extremely compressed laterally, with acute anterior and posterior margins; sides smooth, a longitudinal band of gano-dentine covering the anterior half; a single series of large, compressed, triangular denticles upon the posterior margin.

Pristacanthus securis, Agassiz.

1825. "Défense caudale," E. Deslongchamps, Mém. Soc. Linn. Normandie, vol. ii. p. 271, figs. 1–3.

1837. *Pristacanthus securis*, L. Agassiz, Poiss. Foss. vol. iii. p. 35, pl. viii. *a*. figs. 11–13.

1871. *Pristacanthus securis*, J. Phillips, Geol. Oxford, p. 178, diagr. xxxviii. fig. 10.

1890. *Pristacanthus securis*, A. S. Woodward, Proc. Geol. Assoc. vol. xi. p. 290, pl. iii. fig. 2.

Type. Caen Museum, and Royal College of Surgeons, London.

The type species.

Form. & Loc. Great Oolite: Caen, Normandy. Stonesfield Slate: near Oxford.

P. 6253. Crushed specimen showing internal cavity; Allemagne, near Caen. *Purchased.*

32726–27. Two specimens, one showing the imperfect tapering distal portion, the other exhibiting the characteristic lateral band of gano-dentine; Allemagne. *Tesson Coll.*

41306. Imperfect distal portion of spine; Allemagne. *Purchased*, 1869.

P. 6254. Two specimens; Allemagne. *Enniskillen Coll.*

A fragment of an Asterolepid appendage from the Devonian of Russia has been erroneously assigned to this genus under the name of *Pristacanthus marinus*, E. von Eichwald (Bull. Soc. Imp. Nat. Moscou, vol. xvii. 1844, p. 826 (*marianus*), and *ibid.* vol. xix. 1846, pt. ii. p. 294, pl. x. figs. 10, 11, and Leth. Rossica, vol. i. 1860, p. 1605).

Genus **CŒLORHYNCHUS,** Agassiz.

[Poiss. Foss. vol. v. pt. i. 1844, p. 92.]

Syn. *Cylindracanthus,* J. Leidy, Proc. Acad. Nat. Sci. Philad. 1856, p. 12.

Spine very long, slender, and gradually tapering, rounded in section, and without denticles; external surface longitudinally ridged and grooved, each ridge corresponding to a wedge-shaped plate, which forms a small sector of the spine. Central cavity relatively small, sometimes in part simple, but usually divided by a median partition; a division plane passing through the middle of the partition, thus allowing the spine to be readily split into two symmetrical halves.

This ichthyodorulite was originally mistaken by Agassiz for the rostrum of a Xiphioid Teleostean, and its truly dermal nature was first demonstrated by W. C. Williamson[1]. A Cretaceous example in the Willett Collection, Brighton Museum, suggests that the fossil may be referable to an undetermined Chimæroid[2].

Cœlorhynchus rectus, Agassiz.

1784. "Pétrification inconnue," Burtin, Oryctogr. Bruxelles, pl. vi. figs. A–E.

1844. *Cœlorhynchus rectus,* L. Agassiz, Poiss. Foss. vol. v. pt. i. p. 92 (name only).

1850. *Cœlorhynchus,* F. Dixon, Foss. Sussex, p. 112, pl. x. figs. 14–17, pl. xi. fig. 26.

1861. *Cœlorhynchus rectus,* R. Owen, Palæontology, ed. 2, p. 172, woodc. fig. 80.

1871. *Cœlorhynchus burtini* and *C. rectus,* H. Le Hon, Prélim. Mém. Poiss. Tert. Belg. p. 14.

1871. *Cœlorhynchus burtinii* and *C. rectus,* P. J. Van Beneden, Bull. Acad. Roy. Belg. [2] vol. xxxi. p. 500.

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[1] Phil. Trans. 1849, p. 471, pl. xliii. figs. 35–37, and *ibid.* 1851, p. 667.

[2] A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. ii. (1888), p. 223.

1874. *Cœlorhynchus rectus* and *C. burtini*, T. C. Winkler, Archiv. Mus. Teyler, vol. iii. p. 303.

1879. *Cœlorhynchus rectus*, A. de Zigno, Mem. R. Istit. Veneto, vol. xxi. p. 784, pl. xv. figs. 16–18.

Type. British Museum.

The type species, attaining a length of not less than 0·45, with a maximum diameter of about 0·015. The superficial longitudinal ridges are normally very sharp, their broad and flat appearance in many fossils being due to post-mortem abrasion.

Form. & Loc. London Clay: Isle of Sheppey. Bracklesham Beds: Sussex. Barton Clay: Hampshire. Middle and Upper Eocene: Belgium and Italy. *Derived* in Red Crag: Suffolk.

38881. Two portions of spines; London Clay, Sheppey. *Bowerbank Coll.*

25859. One of the type specimens, much abraded, figured by Dixon, *op. cit.* pl. xi. fig. 26; Bracklesham. *Dixon Coll.*

25729. Four specimens, three showing the distal extremity in which the degree of tapering and bluntness varies considerably; Bracklesham. *Dixon Coll.*

40276. Fragments; Bracklesham. *Edwards Coll.*

P. 1766–67. Similar specimens; Bracklesham. *Egerton Coll.*

P. 5438. Similar specimens; Bracklesham. *Presented by P. E. Coombe, Esq.*, 1888.

P. 3941. Imperfect spine 0·375 in length, wanting both extremities; Bracklesham. *Enniskillen Coll.*

30890. Portion of small spine; Bramshaw. *Purchased.*

P. 4304. Fragments; Barton Clay, Barton Cliff. *Enniskillen Coll.*

42880. Numerous fragments; Brussels. *Van Breda Coll.*

P. 4305. Fragment; Brussels. *Enniskillen Coll.*

43312. Two fragments; Red Crag, Woodbridge. *Whincopp Coll.*

The following specimens are probably portions of the base of large examples of *C. rectus*, but the longitudinal ridges of the first two exhibit a certain degree of sinuosity, and they may thus be of the form named *C. sinuatus* by Agassiz (Poiss. Foss. vol. v. pt. i. 1844, p. 92), without description:—

P. 6232. Well-preserved specimen; London Clay, Isle of Sheppey. *History unknown.*

P. 4303. Two smaller and more imperfect fragments: Sheppey.
Enniskillen Coll.

Cœlorhynchus gigas, A. S. Woodward.

1888. *Cœlorhynchus gigas*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. i. p. 225.

Type. British Museum.
Form. & Loc. Eocene: Egypt.

893–5. Type specimen, in three fragments, described *loc. cit.*; from the rock of the Great Sphinx.
Presented by Col. Howard Vyse.

Cœlorhynchus cretaceus, Dixon.

1850. *Cœlorhynchus cretaceus*, F. Dixon, Geol. Sussex, pl. xxxii. fig. 10.
1888. *Cœlorhynchus cretaceus*, A. S. Woodward, Proc. Geol. Assoc. vol. x. p. 330, and Ann. Mag. Nat. Hist. [6] vol. ii. p. 225.

Type. Brighton Museum.
Form. & Loc. Upper Chalk: Sussex and Norfolk.

P. 3942. Imperfect typical specimen; (?) Sussex. *Enniskillen Coll.*

48956 a. Fragment; Norwich. *Bayfield Coll.*

The genus is represented from other localities as follows:—

P. 5838. Fragment; Craie de Ciply, Belgium.
Presented by M. Houzeau de Lehaie, 1888.

41860. Abraded fragment; "Eocene, Gerona, Spain."
Presented by S. P. Pratt, Esq., 1870.

P. 1769. Several fragments, probably of the form named *Cylindracanthus ornatus* by J. Leidy, Proc. Acad. Nat. Sci. Philad. 1856, p. 12, and subsequently (*ibid.* p. 302) assigned by that author to *Cœlorhynchus*; Eocene, Clarke's Co., Alabama, U.S.A. *Egerton Coll.*

23284. Impression of part of spine, noticed by Lydekker, Rec. Geol. Surv. India, vol. xx. (1887), p. 70; probably from the Middle Eocene (Nummulitic Series) of Sind, India.

The following species has also been described, but there are no examples in the Collection:—

Cœlorhynchus sulcatus, K. E. Schafhäutl, Süd-Bayerns Leth. Geogn. (1863), p. 249, pl. lxiv. fig. 5.—Eocene; Kressenberg, Bavaria. [Munich Museum.]

III. Paired spines of which some may have been placed in front of fins, but of which many are broad, with insignificant base of insertion, and must have been arranged as independent dermal armour.

Genus **MACHÆRACANTHUS,** Newberry.

[Bull. National Institute, 1857, p. 6.]

Syn. *Machærius,* M. Rouault, Comptes Rendus, vol. xlvii. 1858, p. 102 (preoccupied).

Spines, so far as known, elongated, tapering, more or less curved, and somewhat laterally compressed, with sharp edges and a large longitudinal ridge on each side; central cavity extending nearly to the apex; external surface covered with a thin layer of ganodentine, smooth, finely punctate, or longitudinally striated.

Machæracanthus sulcatus, Newberry.

1843. "Ichthyodorulite," J. Hall, Nat. Hist. New York, pt. iv. p. 174, woodc. fig. 69.
1857. *Machæracanthus sulcatus,* J. S. Newberry, Bull. Nat. Inst. p. 6.
1870. *Machairacanthus sulcatus,* E. R. Lankester, Geol. Mag. vol. vii. p. 398, woodc. fig. 3.
1873. *Machæracanthus sulcatus,* J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. p. 305.
1886. *Machæracanthus sulcatus,* T. H. Lennox, Proc. Canad. Inst. vol. iii. p. 120.
1889. *Machæracanthus sulcatus,* J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi.), p. 40, pl. xxix. fig. 5.

Type. Delaware University, Ohio.

Form. & Loc. Lower Devonian (Corniferous Limestone): Ohio, New York, Ontario, and Canada.

P. 6216. Impression of part of spine, apparently the specimen figured by Lankester, *loc. cit.*; Gaspé, Canada.
Presented by Sir J. William Dawson, K.C.M.G., 1890.

The following species are also recognized, but there are no examples in the Collection :—

Machæracanthus abnormis : *Ctenacanthus abnormis,* C. G. Giebel, Abh. Naturw. Vereins Provinz Sachsen u. Thüringen, vol. i. (1858), p. 264, pl. i. fig. 12; J. Barrande, Syst. Silur. Bohême, Suppl. to vol. i. (1872), p. 628; E. Kayser, Abh. geol. Specialk. Preuss. u. Thüring. Staaten, vol. ii. pt. iv.

(1878), p. 3, pl. i. fig. 19: (?) *Ichthyodorulites*, F. A. Roemer, Palæontogr. vol. iii. (1852), p. 75, pl. xi. fig. 26.—Lower Devonian; Harz Mts.

Machæracanthus archiaci: *Machærius archiaci*, M. Rouault, Comptes Rendus, vol. xlvii. (1858), p. 103.—Lower Devonian; Brittany.

Machæracanthus bohemicus, O. Novak, Sitzungsb. k. böhm. Gesell. Wiss. 1886 (1887), p. 663, pl. i. fig. 14: *Ctenacanthus bohemicus*, J. Barrande, Syst. Silur. Bohême, Suppl. to vol. i. (1872), p. 641, pls. xxviii., xxx., xxxiv.: *Machæracanthus*, E. Kayser, Neues Jahrb. 1884, vol. ii. p. 82.—Lower Devonian; Bohemia. [Royal Bohemian Museum, Prague.]

Machæracanthus larteti: *Machærius larteti*, M. Rouault, *tom. cit.* (1858), p. 102.—Lower Devonian; Brittany. [Type species of *Machærius*.]

Machæracanthus major, J. S. Newberry, Bull. Nat. Inst. (1857), p. 6, and Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 304, pl. xxv. fig. 2, and Palæoz. Fishes N. America (1889), p. 39, pl. xxix. fig. 4.—Lower Devonian (Corniferous Limestone); Ohio. [Columbia College, New York.]

Machæracanthus peracutus, J. S. Newberry, *tom. cit.* (1857), p. 6, and *tom. cit.* (1873), pp. 303, 305, pl. xxix. fig. 6, and woodc., and *tom. cit.* (1889), pp. 38, 40, pl. xxix. fig. 6, and woodc.—Corniferous Limestone; Ohio. [The type species. Columbia College, New York.]

Genus **HAPLACANTHUS,** Agassiz.

[Poiss. Foss. V. G. R. 1845, p. 114.]

Spines of small size, elongated, tapering, more or less curved and laterally compressed, apparently without posterior denticles; a deep longitudinal groove separating a narrow anterior rim from the rest of the spine, which has smooth sides or exhibits faint longitudinal striæ.

As remarked by von Eichwald, spines of this form may be compared with those of *Cheiracanthus* and allied Acanthodian genera.

Haplacanthus marginalis, Agassiz.

1845. *Haplacanthus marginalis*, L. Agassiz, Poiss. Foss. V. G. R. p. 114, pl. xxxiii. figs. 4–6.

1846. *Onchus tenuisulcatus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xix. pt. ii. p. 292, pl. x. figs. 6, 7.

1860. *Haplacanthus tenuisulcatus*, E. von Eichwald, Leth. Rossica, vol. i. p. 1599, pl. lvii. fig. 19.

The type species.

Form. & Loc. Devonian: near St. Petersburg.

P. 2252. Fragment of spine. *Egerton Coll.*

Genus **HETERACANTHUS,** Newberry.

[Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 65.]

Spines small or of moderate size, much laterally compressed, broad and triangular, and gently arched; internal cavity very large, opening by a long fissure at the convex border; base of insertion short or absent. Sides of exserted portion ornamented with broad, flattened, smooth, longitudinal ridges, bifurcating and intercalated towards the base; the ridges having finely crenulated margins, separated by very narrow, fissure-like sulci.

Heteracanthus politus, Newberry.

1889. *Heteracanthus politus*, J. S. Newberry, *tom. cit.* p. 66, pl. xxi. figs. 4, 5.

Type. Columbia College, New York.

The type species, not represented in the Collection.

Form. & Loc. Hamilton Group (Upper Devonian): Milwaukee, Wisconsin.

Heteracanthus heterogyrus (Agassiz).

[Plate III. fig. 6.]

1845. *Onchus heterogyrus*, L. Agassiz, Poiss. Foss. V. G. R. p. 117, pl. xxxiii. figs. 16–18.

Type. Unknown.

This species is assigned to *Heteracanthus* on account of the characters of the superficial ornamentation. Both the type specimen and the example recorded below appear to be fragmentary, thus not exhibiting the original form of the spine.

Form. & Loc. Devonian: N.W. Russia.

P. 2248. Fragment of spine, partly shown, of twice the natural size, in Pl. III. fig. 6. The ornament is precisely similar to that of the type species, which the writer has examined at Columbia College. *Egerton Coll.*

Genus **PSAMMOSTEUS,** Agassiz.

[Poiss. Foss. V. G. R. 1845, p. 103.]

Syn. *Placosteus,* L. Agassiz, Poiss. Foss. vol. i. 1844, p. xxxiii (name only).
Psammolepis, L. Agassiz, *ibid.* p. xxxiv (name only).

Spines and dermal plates of moderate size, the former much laterally compressed, usually unsymmetrical, broad and triangular, with a large internal cavity and short base of insertion. External surface ornamented with numerous, closely arranged, rounded or elongated tubercles of gano-dentine, usually stellate and rarely arranged in regular series.

As pointed out by Agassiz and Pander, the histological structure of these ichthyodorulites is suggestive of that of Selachian dermal armour; and in external characters they are most nearly paralleled by *Oracanthus,* as described below.

Psammosteus mæandrinus, Agassiz.

1844. *Placosteus mæandrinus,* L. Agassiz, Poiss. Foss. vol. i. p. xxxiii (name only).
1845. *Psammosteus mæandrinus,* L. Agassiz, Poiss. Foss. V. G. R. p. 104, pl. xxvii. figs. 5, 6.
1845. *Ctenacanthus serrulatus,* L. Agassiz, *ibid.* p. 119, pl. xxxiii. fig. 24.
1857. *Asterolepis* ?, C. H. Pander, Placoderm. devon. Syst. p. 20, pl. vii. figs. 16–18.
1858. *Psammosteus mæandrinus,* G. Kade, Programm k. Realschule zu Meseritz, p. 11, figs. 2–5.
1860. *Psammosteus mæandrinus,* E. von Eichwald, Leth. Rossica, vol. i. p. 1516.
1880. *Coccosteus megalopteryx,* H. Trautschold (*errore*), Verhandl. russ. k. mineral. Gesell. St. Petersburg, p. 152, pl. vi. fig. 1, pl. vii. fig. 2.
1889. *Coccosteus megalopteryx,* H. Trautschold (*errore*), Zeitschr. deutsch. geol. Gesell. vol. xli. p. 36.
1890. "Selachian appendages," R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. v. p. 134.

Type. Unknown.
The type species.
Form. & Loc. Devonian: N.W. Russia.

P. 4493. Two spines, imperfect distally, of the form assigned to this species by Eichwald, but described as *Coccosteus megalopteryx* by Trautschold; from banks of River Ssjass. In one specimen there are indications of a narrow inserted portion at the base of one side and a much deeper insertion

on the opposite side ; but this feature may possibly be due in part to accidental abrasion towards the proximal end. The convex border of the spine exhibits evidence of wear during life, the ornament having been destroyed.

Purchased, 1884.

35019, a, b. Three fragmentary, short, blunt spines, of a type different from the above, but closely resembling the latter in ornamentation ; from a boulder of Old Red Sandstone, Birnbaum, near Posen, Silesia. The first of the specimens agrees with the spine shown in Pander's fig. 16.

Purchased, 1860.

P. 2229. Impression of ornament and some small fragments in matrix ; Livonia. *Egerton Coll.*

Psammosteus arenatus, Agassiz.

1844. *Placosteus arcuatus*, L. Agassiz, Poiss. Foss. vol. i. p. xxxiii (name only).

1845. *Psammosteus arenatus*, L. Agassiz, Poiss. Foss. V. G. R. p. 105, pl. xxxi. figs. 7–10.

1857. "Ichthyodorulith," C. H. Pander, Placoderm. devon. Syst. p. 102, pl. vii. fig. 22.

1858. *Psammosteus arenatus*, G. Kade, Programm k. Realschule zu Meseritz, p. 10, fig. 14.

Type. Unknown.

By Eichwald (Leth. Rossica, vol. i. p. 1510) the plates thus described are doubtfully associated with the so-called *Asterolepis depressus* ; while the triangular spine figured by Pander is ascribed to *Coccosteus megalopteryx* by Trautschold (Zeitschr. deutsch. geol. Gesell. vol. xli. p. 36).

Form. & Loc. Devonian : N.W. Russia and N. Scotland.

35019 c. Fragment from boulder at Birnbaum, near Posen, Silesia.

Purchased, 1860.

P. 6233. Portion of typical plate ; Riga.

Presented by Sir R. I. Murchison, K.C.B.

P. 709. Fragment in matrix ; Riga. *Egerton Coll.*

P. 4598. Similar, but larger fossil ; Riga. *Enniskillen Coll.*

42453. Two portions of plates said to have been obtained from the Caithness Flagstones of Wick. In physical characters one example much resembles that presented by Sir R. I. Murchison. *Peach Coll.*

Psammosteus paradoxus, Agassiz.

1844. *Psammolepis paradoxus,* L. Agassiz, Poiss. Foss. vol. i. p. xxxiv. (name only).

1845. *Psammosteus paradoxus,* L. Agassiz, Poiss. Foss. V. G. R. p. 104, pl. B. figs. 5, 6, pl. xxvii. figs. 2–4.

Type. Unknown.

Form. & Loc. Devonian: N.W. Russia.

P. 4491. Much abraded plate, with surface ornament partly removed; River Ssjass. *Purchased,* 1884.

P. 5959. Well-preserved portion of plate, 0·005 in thickness; Juchora, River Ssjass. In addition to a general fine rugosity, the inner aspect exhibits a few short, small, irregularly disposed grooves, with raised lateral borders (*cf.* fig. of "*Asterolepis asmussi*" in Pander's Placoderm. devon. Syst. pl. vii. fig. 32). *Purchased,* 1889.

Other plates have also been assigned to *Psammosteus* under the following names:—

Psammosteus granulatus, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 7.—Lower Carboniferous; Kesh, Co. Fermanagh. [Dublin Museum.]

Psammosteus undulatus, L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 106, pl. xxxi. figs. 11, 12: *Placosteus undulatus,* L. Agassiz, Poiss. Foss. vol. i. (1844), p. xxxiii (name only).—Devonian; N.W. Russia.

Psammosteus vermicularis, F. M'Coy, *tom. cit.* p. 7.—Lower Carboniferous; Fallaghloon, Maghera. [Dublin Museum.]

The plate described as follows also exhibits some external resemblance to *Psammosteus*, but its histological structure is unknown:—

Lophosteus superbus, C. H. Pander, Foss. Fische Silur. Syst. (1856), p. 62, pl. vi. fig. 23.—Upper Silurian; Ohhesaar, Island of Oesel.

In general external aspect the spines from the American Corniferous Limestone named *Acanthaspis* (J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. 1875, p. 36) and *Acantholepis* (J. S. Newberry, *ibid.* p. 38) are very suggestive of the triangular ichthyodorulites assigned above to *Psammosteus*: their histological structure,

however, is unknown. Some of these fossils were originally named *Oracanthus abbreviatus*, *O. fragilis*, and *O. granulatus* (J. S. Newberry, Bull. National Institute, 1857), but only the following two species have been fully defined:—

Acanthaspis armatus, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 37, pl. lv. figs. 1-6[1].—Corniferous Limestone (Lower Devonian); Ohio. [Columbia College, New York.]

Acantholepis pustulosus, J. S. Newberry, *ibid.* p. 38, pl. lvi. figs. 1–6[1].—Ibid. [Columbia College, New York.]

Genus **STETHACANTHUS,** Newberry.

[Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 198.]

Spines much laterally compressed, "broadly falcate in outline, the conical summit compressed, with anterior and posterior margins rounded"; base of insertion broad. Convex margin with long sulcus exposing the internal cavity; concave margin at about one-third of its length from the base "rising into a strong, often tumid, shoulder"; sides unornamented, exhibiting the fibrous texture of the spine.

This genus is not represented in the Collection, but the two following species are recognized:—

Stethacanthus altonensis, J. S. Newberry, Palæoz. Fishes N. America (1889), p. 198, pl. xxiv.: *Physonemus altonensis*, St. John & Worthen, Pal. Illinois, vol. vi. (1875), p. 454, pl. xix. figs. 1–3.—Upper St. Louis Limestone; Illinois and Iowa. [Type species.]

Stethacanthus tumidus, J. S. Newberry, *op. cit.* p. 198, pl. xxv. figs. 1, 2.—Berea Grit; Berea, Ohio. [Columbia College, New York.]

In texture and general aspect the spines thus described are so similar to those found with *Gyracanthus*, that it seems not improbable they may truly belong to an Elasmobranch already known by its fin-spines, which have received a distinct name.

[1] Both these descriptions and figures are reprinted in J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), pp. 33–37, pl. xxxi.

Genus **PHYSONEMUS**, M'Coy.

[Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 117.]

Syn. *Xystracanthus*, J. Leidy, Proc. Acad. Nat. Sci. Philad. 1859, p. 3.
Drepanacanthus, Newberry & Worthen, Pal. Illinois, vol. ii. 1866, p. 120.

Spines much laterally compressed, strongly arched, often hook-shaped; base of insertion broad. Sides of exserted portion more or less ornamented with tuberculated longitudinal ridges; small denticles present upon the concave edge.

According to Newberry and Worthen, the form of the inserted portion in the so-called *Drepanacanthus* proves that the spine was arched forwards.

Physonemus arcuatus, M'Coy.

1848. *Physonemus arcuatus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 117.
1855. *Physonemus arcuatus*, F. M'Coy, Brit. Palæoz. Foss. p. 638, pl. iii. 1. fig. 29.
1883. *Physonemus arcuatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 367, pl. xlvii. fig. 8.

Type. Woodwardian Museum, Cambridge.
The type species.
Form. & Loc. Lower Carboniferous Limestone: Armagh and Gloucestershire.

P. 2239. Base of spine; Armagh. *Egerton Coll.*

P. 2519. Distal portion of spine; Armagh. This is probably the specimen assigned provisionally to *Chalazacanthus verrucosus* by J. W. Davis, *loc. cit.* p. 371. *Enniskillen Coll.*

P. 2520–21. Two more imperfect specimens, both "decorticated"; Armagh. *Enniskillen Coll.*

38022. Similar specimen; Black Rock, Bristol. *Purchased*, 1863.

Physonemus attenuatus, Davis.

1883. *Physonemus attenuatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 369, pl. xlvii. fig. 10.

Type. Formerly in the Enniskillen Collection[1].
Form. & Loc. Lower Carboniferous Limestone: Armagh.

[1] See Introduction.

P. 2869. Four imperfect and much abraded specimens.
Enniskillen Coll.

P. 2870. Much abraded smaller spine, doubtfully of this species; Hook Point, Wexford. *Enniskillen Coll.*

Physonemus hamatus (Agassiz).

1837. *Onchus hamatus*, L. Agassiz, Poiss. Foss. vol. iii. p. 9, pl. i. figs. 7, 8.
1883. *Physonemus hamatus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 370, pl. xlvii. figs. 9, 11.
1884. *Physonemus hamatus*, J. W. Davis, Quart. Journ. Geol. Soc. vol. xl. p. 617, pl. xxvi. fig. 6.

Type. Bristol Museum.
Form. & Loc. Lower Carboniferous Limestone: Gloucestershire. Upper Carboniferous Limestone: Yorkshire.

P. 4901. Spine of the form assigned to this species by J. W. Davis, *loc. cit.* (1884); Yoredale Rocks, Wensleydale, Yorkshire.
Horne Coll.

The following species have also been described, but there are no examples in the Collection:—

Physonemus acinaciformis: *Xystracanthus acinaciformis*, St. John & Worthen, Pal. Illinois, vol. vi. (1875), p. 459, pl. xx. fig. 2.—Coal-Measures; Illinois.

Physonemus anceps: *Drepanacanthus anceps*, Newberry & Worthen, Pal. Illinois, vol. ii. (1866), p. 122, pl. xii. fig. 8: *Xystracanthus anceps*, St. John & Worthen, *op. cit.* vol. vi. p. 458.—Coal-Measures; Illinois. [Type of *Drepanacanthus*.]

Physonemus arcuatus: *Xystracanthus arcuatus*, J. Leidy, Proc. Acad. Nat. Sci. Philad. 1859, p. 3, and Ext. Vert. Fauna W. Territ. (Rep. U.S. Geol. Surv. vol. i. 1873), p. 312, pl. xvii. fig. 25.—Upper Coal-Measures; Kansas. [Type of *Xystracanthus*, requires new specific name.]

Physonemus carinatus, St. John & Worthen, *op. cit.* vol. vi. p. 452, pl. xviii. figs. 4, 5.—Kinderhook Limestone; Illinois.

Physonemus chesterensis, St. John & Worthen, *op. cit.* vol. vi. p. 455, pl. xix. fig. 4.—Chester Limestone; Illinois.

Physonemus depressus, St. John & Worthen, *op. cit.* vol. vi. p. 452, pl. xviii. fig. 3.—Kinderhook Limestone; Illinois.

Physonemus falcatus, St. John & Worthen, *op. cit.* vol. vii. (1883), p. 252, pl. xxiv. fig. 6.—St. Louis Limestone; Missouri.

Physonemus gemmatus: *Drepanacanthus gemmatus*, Newberry & Worthen, Pal. Illinois, vol. ii. (1866), p. 123, pl. xiii. fig. 1.—Keokuk Limestone; Iowa.

Physonemus giganteus: *Xystracanthus giganteus*, W. Waagen, Salt-Range Fossils (Palæont. Indica, ser. 13), vol. i. (1880), p. 76, pl. vii. fig. 2.—Productus-Limestone; Salt Range, Punjab, India.

Physonemus gigas, Newberry & Worthen, *op. cit.* vol. iv. (1870), p. 373, pl. ii. fig. 1.—Burlington Limestone, Illinois.

Physonemus koninckı: *Xystracanthus koninckı*, M. Lohest, Ann. Soc. Géol. Belg. vol. xi. (1883), p. 322, pl. v. figs. 2, 3.—Lower Carboniferous (Ampélite); Belgium.

Physonemus mirabilis: *Xystracanthus mirabilis*, St. John & Worthen, Pal. Illinois, vol. vi. p. 458, pl. xx. fig. 1.—Coal-Measures; Illinois.

Physonemus parvulus, St. John & Worthen, *op. cit.* vol. vi. p. 453, pl. xviii. figs. 11, 12.—Keokuk Limestone; Missouri and Illinois.

Physonemus proclivus, St. John & Worthen, *op. cit.* vol. vi. p. 451, pl. xviii. figs. 1, 2.—Kinderhook Limestone; Illinois.

Physonemus reversus: *Drepanacanthus reversus*, St. John & Worthen, *op. cit.* vol. vi. p. 456, pl. xix. figs. 5, 6, and vol. vii. p. 253, pl. xxiv. fig. 5.—Upper St. Louis Limestone; Illinois and Missouri.

Physonemus stellatus, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 200, pl. xxi. fig. 12.—St. Louis Limestone; Greencastle, Indiana. [Columbia College, New York.]

Two fragments of spines, doubtfully of this genus, from the Productus-Limestone of the Salt Range, Punjab, are named *Xystracanthus gracilis*, W. Waagen (*tom. cit.* 1879, p. 19, pl. i. figs. 2, 5), and *X. major*, W. Waagen (*ibid.* p. 19, pl. ii. fig. 9).

The so-called *Physonemus subteres*, from the Lower Carboniferous Limestone of Armagh, named by Agassiz (Poiss. Foss. vol. iii. 1843, p. 176), and described by F. M'Coy (Brit. Palæoz. Foss. 1855, p. 638, pl. iii. r. fig. 30) and J. W. Davis (Trans. Roy. Dublin Soc. [2] vol. i. 1883, p. 368, pl. xlvii. fig. 12), does not appear to belong to this genus; and a very doubtful fossil from the Carboniferous Limestone of Moscow is named *Drepanacanthus pectinifer*, H. Trautschold, Nouv. Mém. Soc. Imp. Nat. Moscou, vol. xiii. (1874), p. 297, pl. xxviii. fig. 10.

The fragments of spines, from the Lower Carboniferous of the United States, named *Batacanthus*, St. John & Worthen (*op. cit.*

vol. vi. p. 468), are perhaps of the same type as *Physonemus*. Two species are recognized:—*B. baculiformis*, St. John & Worthen (*ibid.* p. 469, pl. xxi. figs. 4–8), from the Keokuk Limestone of Missouri, Iowa, and probably Illinois; and *B. stellatus*, St. John & Worthen (*ibid.* p. 470, pl. xxi. figs. 1–3), previously named *Drepanacanthus? stellatus*, Newberry & Worthen (Pal. Illinois, vol. ii. 1866, p. 125, pl. xii. fig. 7), from the Keokuk Limestone of Illinois. A third spine is also doubtfully placed here, namely, *B.? necis*, St. John & Worthen (*op. cit.* vol. vii. p. 253, pl. xxv. fig. 4), from the Keokuk Limestone of Iowa; and it is suggested (*op. cit.* vol. vi. p. 468) that the so-called *Myriacanthus semigranulatus*, H. Romanowsky (Bull. Soc. Imp. Nat. Moscou, 1864, pt. ii. p. 167, pl. iv. fig. 34), may be of the same generic type.

Genus **STICHACANTHUS,** Koninck.

[Faune Calc. Carb. Belg. pt. i. 1878, p. 70.]

Spines much laterally compressed, straight or slightly arched, broad and triangular, or narrow and elongated; sides of exserted portion ornamented with longitudinal series of rounded tubercles placed upon low ridges, except towards the base, where the ridges disappear.

Stichacanthus cœmansi, Koninck.

1878. *Stichacanthus cœmansi*, L. G. de Koninck, Faune Calc. Carb. Belg. pt. i. p. 71, pl. vii. figs. 4, 5.

Type. Royal Museum of Natural History, Brussels.

The type species.

Form. & Loc. Lower Carboniferous Limestone: Belgium, Shropshire, and Gloucestershire.

36197. Portion of spine noticed by de Koninck, *op. cit.* p. 71; Oreton, Shropshire. *Purchased*, 1861.

P. 229–30. A much-abraded specimen, and an imperfect spine, with finer ornament, doubtfully of this species; Oreton.
Weaver-Jones Coll.

42240. Terminal portion of spine similar to No. P. 230; Oreton.
Baugh Coll.

Stichacanthus tortworthensis, Davis.

1883. *Stichacanthus tortworthensis*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 532, pl. lxv. fig. 2.

Type. Earl of Ducie, Tortworth Court.

Form. & Loc. Carboniferous Limestone: Gloucestershire and Shropshire.

42234. Portions of a spine of similar proportions to the type specimen; Oreton, Shropshire. The concavely-arched margin is rounded, the opposite truncated by a flat area, which becomes channelled distally. Upon one edge of the flattened area there is a series of relatively large denticles; and on the sides near the base the longitudinal ridges connecting the tubercles disappear. *Baugh Coll.*

42234 a. Basal portion of a similar broad spine; Oreton. *Baugh Coll.*

42236. A much more slender spine of a similar type; Oreton. *Baugh Coll.*

The following specimens only differ from the typical *Stichacanthus* in the fact that the superficial tubercles are not connected even by faint ridges:—

42235. An imperfect small broad spine; Oreton. *Baugh Coll.*

14195. Portion of a small spine, perhaps narrower; Oreton. *Purchased*, 1868.

42245. Proximal portion of a small spine showing a large base of insertion; Oreton. *Baugh Coll.*

The following species is also doubtfully placed here:—

Stichacanthus (?) *humilis*, L. G. de Koninck, Faune Calc. Carb. Belg. pt. i. (1878), p. 72, pl. vii. fig. 6.—Lower Carboniferous Limestone; Soignies, Belgium. [Royal Museum Nat. Hist., Brussels.]

Genus **ORACANTHUS,** Agassiz.

[Poiss. Foss. vol. iii. 1837, p. 13.]

Syn. *Platyacanthus,* F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 120.

Pnigeacanthus, St. John & Worthen, Pal. Illinois, vol. vi. 1875, p. 480.

Phoderacanthus, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. 1883, p. 533.

Spines attaining to a very large size, much laterally-compressed, usually unsymmetrical, broad and triangular, rarely elongated and slightly arched; internal cavity very large, base of insertion short or absent. Sides of exserted portion ornamented by large tubercles, with a tendency to arrangement in transverse series, sometimes fused.

As observed by J. W. Davis[1], the broad triangular spines of this genus are unsymmetrical and must have been arranged in pairs; the lower margin of one side of each spine being straight, while the internal cavity on the other side is exposed by a great excavation. Such spines have subsequently been discovered by R. H. Traquair[2], forming a pair of backwardly-directed weapons behind the head of an Elasmobranch; and microscopical sections have proved the absence of bone-corpuscles in their structure. The spines were originally supposed by Agassiz[3] to be referable to *Orodus*; arguments in favour of their pertaining to *Psammodus* were afterwards discussed by R. Etheridge, Jun.[4]; and more recently they have been regarded by Inostranzeff[5] as not improbably the spines of *Polyrhizodus*.

The narrow elongated spines seem to be homologous with the typical spines named *Gyracanthus*, while the broader examples correspond to the thin, hollow, triangular bodies also met with in the last-named genus.

Oracanthus milleri, Agassiz.

[Plate I. fig. 3.]

1837. *Oracanthus milleri,* L. Agassiz, Poiss. Foss. vol. iii. p. 13, pl. iii. figs. 1–4.

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[1] Trans. Roy. Dublin Soc. [2] vol. i. p. 530, pl. lxiv. fig. 1.

[2] Geol. Mag. [3] vol. v. (1888), p. 86.

[3] Poiss. Foss. vol. iii. p. 171.

[4] Geol. Mag. [2] vol. iv. (1877), p. 308.

[5] Trudui St. Peterb. Obshch. Estest-Ispuit. vol. xix. (1888), p 16.

1837. *Oracanthus minor*, L. Agassiz, *ibid.* p. 16, pl. iii. figs. 5, 6. [Bristol Museum.]
1843. *Oracanthus confluens*, L. Agassiz, *ibid.* p. 177 (name only).
1855. *Oracanthus milleri*, F. M'Coy, Brit. Palæoz. Foss. p. 634.
1877. *Oracanthus milleri*, R. Etheridge, Jun., Geol. Mag. [2] vol. iv. p. 307, pl. xiii. figs. 4–6.
1878. *Oracanthus milleri*, L. G. de Koninck, Faune Calc. Carb. Belg. p. 69, pl. v. fig. 10.
1883. *Oracanthus milleri*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 525, pl. lxiii. figs. 1–4, pl. lxiv., pl. lxv. figs. 3, 4 (? also pl. lxii.).

Type. Bristol Museum.

The type species.

Form. & Loc. Lower Carboniferous Limestone: Gloucestershire, Lanarkshire, and Armagh. Upper Carboniferous Limestone: Visé, Belgium.

28857. Imperfect spine, originally measuring 0·3 in length, and 0·125 across the base; Bristol. *Purchased*, 1854.

22665. Imperfect similar spine, with an attenuated smooth terminal portion, and two fragments; Bristol. *Purchased*, 1848.

P. 2241. Portion of similar spine free from matrix; Bristol. *Egerton Coll.*

P. 3125–6, P. 3130. Imperfect large spine, and two fragments; Bristol. *Enniskillen Coll.*

P. 3128. Smaller specimen, with one narrow face broken away, and the boundary of the base much obscured on one side; figured by J. W. Davis, *loc. cit.* pl. lxiv. fig. 1; Bristol. *Enniskillen Coll.*

34983. Portion of a very small spine; Bristol. *Purchased*, 1860.

P. 2873–5. Small broad spines figured by J. W. Davis, *loc. cit.* pl. lxiii. figs. 1–3; Armagh. *Enniskillen Coll.*

P. 3131. More imperfect similar spine; Armagh. *Enniskillen Coll.*

P. 3129. Imperfect more elongated spine; Armagh. *Enniskillen Coll.*

P. 3132–3. Five terminal extremities of spines, and three fragments; Armagh. *Enniskillen Coll.*

P. 3135. Long slender dermal plate, with spatulate extremity, described and figured by J. W. Davis, *loc. cit.* p. 529, pl. lxv. fig. 3; Armagh. *Enniskillen Coll.*

P. 3136–7. Two more imperfect examples of the same, one figured *loc. cit.* pl. lxv. fig. 4; Armagh. *Enniskillen Coll.*

P. 2887. Smaller portion probably of a similar plate, figured *loc. cit.* pl. lxii. fig. 13; Armagh. *Enniskillen Coll.*

The following spines may also pertain to this species, but differ from the foregoing in their slenderness, and in the fusion of the superficial tubercles into oblique transverse ridges:—

P. 2238. Fragment of a small spine, narrow and straight; Armagh. *Egerton Coll.*

P. 3134, P. 3134 a. Larger portion of a similar spine, free from matrix; also a fragment; Armagh. The spine (Pl. I. fig. 3) is much compressed, with the convex edge acute, and worn at the distal end; the opposite edge being straight and flat, or longitudinally channelled. So far as preserved, the specimen seems to be bilaterally symmetrical; and the oblique lateral ridges are inclined in an exactly opposite direction to those of *Gyracanthus*. *Enniskillen Coll.*

P. 3127. Remains of a larger more arched spine; Castle Espie, Co. Down, Ireland. *Enniskillen Coll.*

The numerous small dermal plates mentioned below are also provisionally associated with *Oracanthus milleri* by J. W. Davis, *loc. cit.* They are thin, consist of vascular dentine, and are externally ornamented with rounded ganoine-tubercles, irregularly disposed. Their nearest known analogues are perhaps to be found in the dermal plates of the Liassic Chimæroid, *Myriacanthus* (p. 43). Similar plates have already been described by F. M'Coy under the names of *Coccosteus*? *carbonarius*[1], *Asterolepis verrucosa*[2], and *Platyacanthus isosceles*[3]; and the triangular forms are named *Pnigeacanthus* by St. John & Worthen, *loc. cit.*

All these specimens were obtained from the Lower Carboniferous Limestone of Armagh, and are from the Enniskillen Collection.

P. 2876–7. Elongated symmetrical plate, bifurcated at one extremity, and portion of a similar plate, figured, *loc. cit.* pl. lxii. figs. 1, 2 ("central dorsal bone of cranium").

[1] Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 9. [Geol. Soc. London.]
[2] *Ibid.* p. 9. [Geol. Soc. London.]
[3] *Ibid.* p. 120. [Geol. Soc. London.]

P. 2878. Elongated bilaterally-symmetrical plate pointed at one extremity, figured, *loc. cit.* pl. lxii. fig. 3 ("jugular plate? or sphenoid bone").

P. 2886. Much-broken plate, figured, *loc. cit.* pl. lxii. fig. 12 ("jugular plate?").

P. 2881. Unsymmetrical plate, figured, *loc. cit.* pl. lxii. fig. 6 ("cheek-plate or operculum").

P. 2879. Nearly similar smaller plate, figured, *loc. cit.* pl. lxii. fig. 4 ("upper jaw?").

P. 2882. Elongated unsymmetrical pointed plate, figured, *loc. cit.* pl. lxii. fig. 7 ("lower jaw").

P. 2880, P. 2883–5. Irregularly shaped plates, figured, *loc. cit.* pl. lxii. figs. 5, 8, 10, 11 ("head-bones").

P. 2888, P. 2901. Imperfect small dermal plates or spines, mostly triangular.

Oracanthus pustulosus, Agassiz.

1837. *Oracanthus pustulosus,* L. Agassiz, Poiss. Foss. vol. iii. p. 15, pl. ii. figs. 3, 4.

1883. *Phoderacanthus grandis,* J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 534, pl. lxv. fig. 1. [British Museum.]

Type. Bristol Museum.

Form. & Loc. Lower Carboniferous Limestone: Bristol, Gloucestershire.

P. 4716. Type specimen of *Phoderacanthus grandis,* Davis, described and figured, *loc. cit.* *Presented by the Earl of Ducie,* 1884.

Oracanthus pnigeus, Newberry & Worthen.

1866. *Oracanthus pnigeus,* Newberry & Worthen, Pal. Illinois, vol. ii. p. 117, pl. xii. fig. 3.

1875. *Pnigeacanthus deltoides,* St. John & Worthen, Pal. Illinois, vol. vi. p. 480.

1883. *Pnigeacanthus pnigeus,* St. John & Worthen, *op. cit.* vol. vii. p. 260.

Form. & Loc. Lower Carboniferous (Keokuk Limestone): Iowa and Illinois, U.S.A.

P. 2900. Imperfect specimen, probably of this species; Warsaw, Illinois. *Enniskillen Coll.*

The following species of *Oracanthus* have also been described, but, in some cases, the distinctive features are very slight, and if such were regarded as of specific value in Britain, *O. milleri* would be considerably subdivided :—

Oracanthus armigerus, R. H. Traquair, Trans. Edinb. Geol. Soc. vol. v. (1887), p. 313 (name only), and Geol. Mag. [3] vol. v. (1888), p. 86.—Calciferous Sandstones; Abden, Fife, and Eskdale, Dumfries. Carboniferous Limestone; Ayrshire. [Collection of R. Craig, Esq., and also portion of fish in Edinburgh Museum.]

Oracanthus? obliquus, St. John & Worthen, Pal. Illinois, vol. vi. (1875), p. 477, pl. xxii. fig. 16.—Upper Keokuk Limestone; Illinois.

Oracanthus rectus, St. John & Worthen, *op. cit.* vol. vii. (1883), p. 257, pl. xxv. fig. 3.—Chester Limestone; Illinois.

Oracanthus trigonalis; *Pnigeacanthus trigonalis*, St. John & Worthen, *op. cit.* vol. vii. p. 259, pl. xxiv. fig. 4.—St. Louis Limestone; Illinois.

Oracanthus vetustus, J. Leidy, Proc. Acad. Nat. Sci. Philad. vol. vii. 1856, p. 414, and Journ. Acad. Nat. Sci. Philad. [2] vol. iii. (1856), p. 161, pl. xvi. figs. 1–3; St. John & Worthen, *op. cit.* vol. vii. p. 255, pl. xxiv. fig. 2: *Oracanthus consimilis*, St. John & Worthen, *op. cit.* vol. vi. p. 478, pl. xxii. fig. 15.—Upper St. Louis Limestone; Illinois, Missouri, and Iowa. [Academy of Natural Sciences, Philadelphia.]

Closely related to *Oracanthus* is the very large spine described as follows :—

Antacanthus insignis, G. Dewalque, Ann. Soc. Géol. Belg. vol. v. (1877), p. lx; L. G. de Koninck, Faune Calc. Carb. Belg. pt. i. pp. 72, 73, pl. viii. figs. 1–3.—Lower Carboniferous Limestone; Liége. [University of Liége.]

Genus **GYRACANTHUS**, Agassiz.

[Poiss. Foss. vol. iii. 1837, p. 17.]

Syn. *Mitrodus*, R. Owen, Trans. Odontol. Soc. vol. v. 1867, p. 338.

Spines of two distinct types, the one evidently connected with fins, the other free. *Fin-spines* elongated, robust, more or less arched, irregularly rounded or oval in transverse section, except towards the unworn apex, which is compressed; base of insertion large, with the internal cavity open for a considerable extent pos-

teriorly. The longitudinal mesial line of the anterior face, except near the unworn apex, defined only by the superficial ornament, which consists of parallel, oblique, transverse ridges, diverging in pairs from this line and inclined towards the inserted extremity; posterior face with a narrow unornamented area, sometimes bounded by a series of denticles on one side; unworn apex also destitute of ornament. *Free spines* broad, laterally compressed, usually triangular, sometimes of reniform shape; base-line straight on one side, much excavated on the other, the central cavity very large and its walls thin; exserted portion having a rough fibrous appearance, usually with a few rounded tubercles at the distal pointed end, these sometimes exhibiting a tendency to arrangement in transverse series.

The paired spines have been described in detail by R. H. Traquair[1], who points out that no known British specimens are bilaterally symmetrical. Notwithstanding this peculiarity, Agassiz supposed that they might have armed the dorsal fins; and Kirkby and Atthey[2] seem to have been the first to suggest their pertaining to paired fins. Hancock and Atthey, in 1868[3], considered that a few of the spines exhibited true bilateral symmetry, and might thus be median dorsal; but Traquair regards these as the paired spines of young individuals, those of more mature individuals being much altered in appearance by the continual abrasion of the apex.

The free spines are usually found in intimate association with the fin-spines, and they were thus originally described by Hancock and Atthey[4] as "carpal bones" (*i. e.* basal cartilages of the pectoral fins); an examination of microscopical sections, however, has demonstrated their truly dermal nature[5].

Pectinated shagreen-granules are also met with in association with the spines of *Gyracanthus*, and microscopical sections of these have been described under the name of *Mitrodus quadricornis*, Owen[6].

Gyracanthus formosus, Agassiz.

1825–26. "Fish spine?," J. de C. Sowerby, Zool. Journ. vol. i. p. 252, pl. viii. fig. 9, and *ibid.* vol. ii. p. 22.

1837. *Gyracanthus formosus*, L. Agassiz, Poiss. Foss. vol. iii. p. 17, pl. v. figs. 2–6.

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[1] Ann. Mag. Nat. Hist. [5] vol. xiii. (1884), p. 38.

[2] According to Hancock and Atthey, 1868.

[3] Ann. Mag. Nat. Hist. [4] vol. i. (1868), p. 368.

[4] Ann. Mag. Nat. Hist. [4] vol. i. (1868), p. 369, and *ibid.* vol. ix. (1872), p. 260.

[5] R. H. Traquair, Ann. Mag. Nat. Hist. [5] vol. xiii. (1884), p. 44.

[6] R. Owen, Trans. Odontol. Soc. vol. v. (1867), p. 338, pl. iii.

1837. *Gyracanthus tuberculatus*, L. Agassiz, *ibid.* p. 19, pl. i.*a.* figs. 1–7.
1841. *Gyracanthus formosus*, E. W. Binney, Trans. Manchester Geol. Soc. vol. i. p. 168.
1848. *Gyracanthus* sp., R. Howse, Trans. Tyneside Nat. Field Club, vol. i. p. 237 (assigned to *G. formosus* by W. King, Permian Fossils, 1850, p. 221).
1867. *Mitrodus quadricornis*, R. Owen, Trans. Odontol. Soc. vol. v. p. 338, pl. iii. [Micro. section of dermal tubercle; British Museum.]
1868. *Gyracanthus tuberculatus*, Hancock & Atthey, Ann. Mag. Nat. Hist. [4] vol. i. p. 368.
1872. *Gyracanthus tuberculatus*, Hancock & Atthey, *ibid.* vol. ix. p. 260.
1870–72. *Gyracanthus tuberculatus*, Hancock & Atthey, Nat. Hist. Trans. Northumb. and Durham, vol. iii. p. 108, and vol. iv. p. 421.
1873. *Gyracanthus*, T. P. Barkas, Coal Meas. Palæont. p. 15, figs. 1–5.
1875. *Gyracanthus formosus*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 216, fig. 3.
1875. *Gyracanthus tuberculatus*, J. Ward, *ibid.* p. 217.
1876. *Gyracanthus tuberculatus*, J. W. Davis, Quart. Journ. Geol. Soc. vol. xxxii. p. 334.
1883. *Gyracanthus tuberculatus*, T. Stock, Ann. Mag. Nat. Hist. [5] vol. xii. p. 185, pl. vii. fig. 17 (dermal tubercle).
1884. *Gyracanthus formosus*, R. H. Traquair, Ann. Mag. Nat. Hist. [5] vol. xiii. p. 46.
1890. *Gyracanthus tuberculatus*, J. Ward, Trans. N. Staffs. Inst. Mining Engineers, vol. x. p. 150, pl. iii. fig. 1.

Type. Unknown.

The type species.

Form. & Loc. Coal-Measures[1]: English and Scottish Coal-fields, and Kilkenny and Queen's Co., Ireland.

Unless stated, the precise horizon of the following specimens is unrecorded:—

P. 5240. Portion of large spine; Dudley, South Staffordshire. *Purchased*, 1886.

P. 5242. Very small spine; Knowles Shale, Fenton Park, North Staffordshire. *Purchased*, 1886.

P. 1184. Abraded fragment; Cannel Coal (Middle Coal-Measures), Tingley, Yorkshire. *Presented by the Earl of Enniskillen*, 1882.

[1] The impression of the base of a fin-spine in the Newcastle Museum, recorded by Howse (1848) as obtained from the Lower Permian of Westoe, is now regarded by that author as truly an Upper Carboniferous fossil.

P. 2235. Imperfect spine of moderate size, showing part of a posterior series of small denticles; Lower Coal-Measures, Lowmoor, Yorkshire. *Egerton Coll.*

P. 4179. Fragment; Lowmoor. *Enniskillen Coll.*

P. 6234. Fragment labelled by Agassiz; Leeds. *Egerton Coll.*

P. 4178. Much broken spine; Ruabon, Denbighshire. *Enniskillen Coll.*

Fig. 10.

Fin-spine of *Gyracanthus formosus*, Ag. Coal-Measures; Dalkeith.

36174. Abraded spine of moderate size; Dalkeith, near Edinburgh. *Purchased*, 1861.

P. 2219. Two spines of medium size, and three large specimens; Dalkeith. *Egerton Coll.*

P. 3148. Two similar spines; Dalkeith. *Enniskillen Coll.*

P. 2234. Nearly complete spine 0·405 in length; Dalkeith. *Egerton Coll.*

P. 3142 a. Base of a very large spine, and an imperfect spine of moderate size, said to have been found associated; Carluke, Lanarkshire. *Enniskillen Coll.*

P. 3141, P. 3147. Spine 0·355 in length, and one of moderate size; Carluke. *Enniskillen Coll.*

P. 2290. Fragment of spine; Govan, near Glasgow. *Presented by George Griffiths, Esq.*, 1882.

P. 4180. Imperfect basal portion of large spine, probably of this species; Castlecomer, Kilkenny, Ireland. *Enniskillen Coll.*

41635. Two slabs of shale with dermal tubercles, probably of this species; Low Main Seam, Newsham, near Newcastle-on-Tyne. *Presented by T. P. Barkas, Esq.*, 1869.

P. 6239. Microscopical section of dermal tubercle, probably of this species, the type specimen of *Mitrodus quadricornis*, Owen; Newsham. *Presented by Sir Richard Owen, K.C.B.*, 1890.

The following specimens exhibit a more tuberculated ornament than those enumerated above, and are thus typical examples of the variety *tuberculatus* :—

P. 243. Very small imperfect spine ; Longton, Staffordshire.
Weaver-Jones Coll.

P. 5529. Small spine ; probably from the Black-shale Coal, Tibshelf Colliery, near Alfreton, Derbyshire.
Presented by Edward Wilson, Esq., 1888.

P. 3143–4. Right and left spines of large size, much worn at the apex ; Low Main Seam, Newsham, near Newcastle-on-Tyne. *Enniskillen Coll.*

P. 4176-7. A still larger specimen, 0·16 in circumference at the base ; also an imperfectly preserved smaller spine ; Newsham. *Enniskillen Coll.*

36149. Spine 0·335 in length, with worn apex ; Airdrie, Lanarkshire. *Presented by Mr. Hair*, 1857.

21975 a. A comparatively slender spine, and a much worn larger spine ; Carluke, Lanarkshire. *Purchased*, 1848.

21975. Two small spines ; Carluke. *Purchased*, 1848.

P. 3139–40, P. 3142, P. 3145. Five large spines ; Dalkeith.
Enniskillen Coll.

P. 6235. Fragment of spine ; Dalkeith.

P. 4181. Basal portion of spine ; Queen's Co., Ireland.
Enniskillen Coll.

The following examples of the broad triangular dermal spines of *Gyracanthus formosus* are also contained in the Collection :—

P. 2264. Small specimen measuring about 0·14 in height and 0·09 across the base ; Knowles Shale, Fenton, N. Staffordshire.
Egerton Coll.

P. 3149. Larger specimen ; Longton, N. Staffordshire.
Enniskillen Coll.

P. 3150. Three specimens, apparently exhibiting a few tubercles, either in the form of a superficial ornament, or originally imbedded in an investing integument ; Low Main Seam, Newsham, near Newcastle-on-Tyne. *Enniskillen Coll.*

It still remains uncertain whether the small spine from the Middle Coal-Measures of Tingley, Yorkshire, described under the name of *G. denticulatus*, Davis [1], is not the unworn spine of the young of *G. formosus*, as described by R. H. Traquair [2]. The following specimen is of the same form, but only one posterior series of denticles is displayed:—

P. 2289. Nearly complete spine 0·15 in length, unornamented for a distance of 0·045 from the apex; Coal-Measures, Govan, near Glasgow. *Presented by George Griffiths, Esq.*, 1882.

The small spine from the Calciferous Sandstone Series of Burdiehouse, near Edinburgh, figured by S. Hibbert, Trans. Roy. Soc. Edinb. vol. xiii. (1835), pl. xi. fig. 1, and assigned to *Gyracanthus formosus* by Agassiz (*tom. cit.* p. 17), is of doubtful species. The following are of a similar type:—

P. 6236. Basal fragment of a large spine; Burdiehouse. *Purchased*, 1847.

P. 2243. Broken small spine; Burdiehouse. *Egerton Coll.*

P. 3146. Less imperfect small spine; Burdiehouse. *Enniskillen Coll.*

The following species have also been described, but there are no examples in the Collection:—

Gyracanthus alleni, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 331, pl. xxxvii. fig. 3.—Waverly Group (Cuyahoga Shale); Ohio. [Columbia College, New York.]

Gyracanthus compressus, J. S. Newberry, *ibid.* p. 330, pl. xxxvii. figs. 1, 2.—Waverly Group; Ohio and (?) Indiana. [Columbia College, New York.]

Gyracanthus duplicatus, J. W. Dawson, Acadian Geol. 2nd edit. (1868), p. 210, woodc. fig. 55; J. S. Newberry, Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 124.—Coal-Measures; Nova Scotia. [Redpath Museum, Montreal.]

Gyracanthus incurvus, R. H. Traquair, Geol. Mag. [3] vol. vii. (1890), p. 21.—Lower Devonian; Campbellton, P. Q., Canada. [Edinburgh Museum.]

[1] J. W. Davis, Ann. Mag. Nat. Hist. [5] vol. vi. (1880), p. 373, woodcut.
[2] Ann. Mag. Nat. Hist. [5] vol. xiii. (1884), p. 40

Gyracanthus inornatus, J. S. Newberry, Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 177, pl. xxiii. fig. 5.—Waverly Group; Wayne Co., Ohio. [Columbia College, New York.]

Gyracanthus magnificus, J. W. Dawson, *op. cit.* 2nd edit. p. 210; J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 57.—Lower Carboniferous Limestone; Cape Breton. [Halifax Museum, Nova Scotia.]

Gyracanthus nobilis, R. H. Traquair, Geol. Mag. [2] vol. x. (1883), p. 542, and Ann. Mag. Nat. Hist. [5] vol. xiii. (1884), p. 44: *G. tuberculatus*, R. H. Traquair (*non* Agassiz), Geol. Mag. [2] vol. viii. (1881), p. 34.—Middle Carboniferous Limestone; Edinburgh and Fifeshire. [Collection of Dr. R. H. Traquair.]

Gyracanthus obliquus, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 117, and Brit. Palæoz. Foss. (1855), p. 629, pl. iii. K. figs. 13, 14.—Lower Carboniferous; Moyheeland, near Draperstown, Ireland. [Woodwardian Museum, Cambridge.]

Gyracanthus sherwoodi, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 119, pl. xviii. fig. 4.—Catskill Group; Pennsylvania. [Columbia College, New York.]

Gyracanthus youngi, R. H. Traquair, Geol. Mag. [2] vol. x. (1883), p. 543, and Ann. Mag. Nat. Hist. [5] vol. xiii. (1884), p. 47.—Middle Carboniferous Limestone; Scottish Coalfield. [Collection of Dr. R. H. Traquair.]

Gyracanthus ornatus, Agassiz (Poiss. Foss. vol. iii. p. 177), from the Welsh Coal-Measures, is named only, and *G. alnwicensis*, Agassiz (*ibid.* p. 19, pl. i. *a*. fig. 8), from the Carboniferous Limestone of Alnwick, Northumberland, is too imperfectly defined for recognition. The so-called *G.? cordatus*, St. John & Worthen (Pal. Illinois, vol. vii. 1883, p. 251, pl. xxvi. fig. 4), from the Keokuk Limestone of Iowa, does not belong to this genus.

The American pectoral spines of *Gyracanthus* are more laterally compressed than any yet known in Europe.

Genus **AGANACANTHUS,** Traquair.

[Geol. Mag. [3] vol. i. 1884, p. 64.]

Paired spines resembling the fin-spines of *Gyracanthus* in shape, but relatively shorter and stouter, and destitute of any superficial

ornament or layer of ganoine; an unsymmetrical double longitudinal series of denticles on the posterior aspect distally.

This genus is not represented in the Collection, and is known only by the type species:—

Aganacanthus striatulus, R. H. Traquair, *loc. cit.* p. 64.—Middle Carboniferous Limestone (Blackband Ironstone): Borough Lee, near Edinburgh. [Collection of Dr. R. H. Traquair.]

Probably to this group of Ichthyodorulites may also be assigned the following genus and species:—

Gomphacanthus acutus, J. W. Davis, Quart. Journ. Geol. Soc. vol. xl. (1884), p. 618, pl. xxvi. fig. 9.—Lower Carboniferous (Yoredale Rocks); Wensleydale, Yorkshire. [York Museum.]

IV. Spines probably not placed in advance of fins, but most nearly resembling the head-spines of the male Chimæroids and some Mesozoic Cestraciont Sharks (e. g. *Hybodus*).

Genus **ERISMACANTHUS**, M'Coy.

[Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 118.]

Syn. *Cladacanthus*, J. W. Davis (*ex* Agassiz, MS.), Trans. Roy. Dublin Soc. [2] vol. i. 1883, p. 364.

Basal portion of spine broad, laterally compressed, not deeply inserted, soon bifurcating above into two slender divergent branches in the same vertical plane; one branch considerably arched, keeled, and pointed distally, with a series of denticles upon the concave margin; the other branch longer, not tapering to a point, but terminating in a cluster of elongated tubercles. An internal cavity extending throughout the spine. Superficial ornament of exserted portion consisting of tubercles and sulcations, the latter predominating in the short pointed branch of the spine.

Erismacanthus jonesi, M'Coy.

1843. *Cladacanthus paradoxus*, L. Agassiz, Poiss. Foss. vol. iii. p. 176 (name only).

1848. *Erismacanthus jonesii*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 119.

1848. *Dipriacanthus falcatus*, F. M'Coy, *ibid.* p. 121. [Mus. Geol. Soc. London.]

1855. *Erismacanthus jonesii*, F. M'Coy, Brit. Palæoz. Foss. p. 628, pl. iii. K. figs. 26, 27.

1883. *Cladacanthus paradoxus*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 365, pl. xlvii. figs. 1–5. [*Olim* Enniskillen Coll. See Introduction.]

1884. *Cladacanthus paradoxus*, J. W. Davis, Quart. Journ. Geol. Soc. vol. xl. p. 617, pl. xxvi. figs. 1–5.

Type. Woodwardian Museum, Cambridge.

The type species.

Form. & Loc. Lower Carboniferous Limestone: Armagh. Yoredale Rocks: Yorkshire.

P. 2895–6. Six broken spines, and seven examples of the branches; Armagh. *Enniskillen Coll.*

P. 2897. Two examples of the longer branch of the spine, displaying large terminal tubercles; Armagh. *Enniskillen Coll.*

Erismacanthus major (Davis).

1883. *Cladacanthus major*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 366, pl. xlvii. figs. 6, 7.

Type. Formerly in the Enniskillen Collection (see Introduction).

Form. & Loc. Lower Carboniferous Limestone: Armagh.

P. 2898–9. Five imperfect specimens of the pointed branch of the spine. *Enniskillen Coll.*

The following specimen is supposed to have been obtained from the Lower Carboniferous Limestone of Bristol:—

P. 6257. The arched portion of a spine as large as *E. major*. The keel on the convex margin is very broad, and the denticles on the opposite margin large, broad, and closely arranged; the sides are ornamented with fine longitudinal ridges, with a few small tubercles near the base.

History unknown.

The following species has also been described:—

Erismacanthus maccoyanus, St. John & Worthen, Pal. Illinois, vol. vi. (1875), p. 461, pl. xxii. figs. 1–5.—St. Louis Limestone; Illinois and Missouri, U.S.A.

There is also a single specimen in the Collection from the Lower Carboniferous Limestone of Armagh (**P. 2896.** *Enniskillen Coll.*), which may possibly be the long branch of a distinct form of spine

of *Erismacanthus*, but cannot be certainly determined. The spine is laterally compressed, gently arched, tapering, and ornamented with fine superficial tubercles.

The imperfect Ichthyodorulites from the Lower Carboniferous of the United States, described under the names of *Gampsacanthus*, St. John & Worthen (Pal. Illinois, vol. vi. 1875, p. 471), and *Lecracanthus*, St. John & Worthen (*ibid.* p. 475), appear to be fragments of *Erismacanthus*-shaped spines. To the former "genus" are assigned *G.*? *latus*, St. John & Worthen (*ibid.* p. 474, pl. xxii. fig. 14), from the Keokuk Limestone of Missouri: *G. squamosus*, St. John & Worthen (*ibid.* p. 473, pl. xxii. fig. 13), from the Upper St. Louis Limestone of Missouri; and *G. typus*, St. John & Worthen (*ibid.* p. 472, pl. xxii. fig. 12), from the Upper St. Louis Limestone of Illinois and Missouri. *Lecracanthus* has only a single species, *L. unguiculus*, St. John & Worthen (*ibid.* p. 476, pl. xxii. figs. 10, 11), from the Upper St. Louis Limestone of Missouri and Illinois.

A fragment, probably of a similar nature, from the Lower Carboniferous Limestone of Armagh, forms the type of *Dipriacanthus*, F. M'Coy (Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 121), with the single species, *D. stokesii*, F. M'Coy (*ibid.* p. 121, and Brit. Palæoz. Foss. p. 627, pl. iii. K. fig. 18), noticed later by J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. (1883), p. 360, pl. xlviii. fig. 10. [Woodwardian Museum, Cambridge.]

Genus **LISTRACANTHUS,** Newberry & Worthen.

[Pal. Illinois, vol. iv. 1870, p. 371.]

Spine small, gently arched, and much laterally compressed, expanding and abruptly truncated at the base. Sides ornamented with numerous acute longitudinal ridges; the concave and convex margins provided with many divergent, slender denticles, pointing towards the apex of the spine.

The type species is *L. hystrix*, Newberry & Worthen (*tom. cit.* p. 372, pl. ii. fig. 3), from the Coal-Measures of Illinois and Ohio[1]. Spines from the Upper Carboniferous Limestone Series of Mons, Belgium, are also assigned to this species by L. G. de Koninck (Faune Calc. Carbf. Belg. pt. i. 1878, p. 75, pl. v. fig. 11), and the following specimen resembles the latter:—

47307. Spine 0·015 in length, but wanting the apex; Castiaux, near Mons, Belgium. In this specimen the alternate

[1] J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 337, and *ibid.* vol. ii. pt. ii. (1875), p. 56, pl. lix. fig. 5.

denticles of the concave margin appear to be directly continuous with the lateral ribs.

Presented by Prof. L. G. de Koninck, 1876.

The following species have also been described :—

Listracanthus beyrichi, A. von Koenen, Neues Jahrb. 1879, p. 341, pl. vii. fig. 1 : *Pamphractus hydrophilus*, H. Heymann (*errore*), Sitzungsb. niederrhein. Gesell. 1870, p. 217.—Culm-Measures ; Herborn, Nassau.

Listracanthus hildrethi, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 56, pl. lix. fig. 6.—Carboniferous ; Ohio. [Marietta College, Ohio.]

A species of this genus from the Calciferous Sandstones of East Kilbride, Lanarkshire, is also preserved in the collection of Dr. John Hunter, Braidwood, near Carluke.

Genus **BYSSACANTHUS,** Agassiz.

[Poiss. Foss. Vieux Grès Rouge, 1845, pp. 111, 116.]

Basal portion of spine broad, not deeply inserted, with a large central cavity, tapering above and passing into a cylindrical elongated portion, straight or slightly arched, with a blunt apex. The surface of the cylindrical portion ornamented with coarse longitudinal ridges, diverging and fewer upon the broad basal portion.

Byssacanthus crenulatus, Agassiz.

1845. *Byssacanthus crenulatus*, L. Agassiz, *op. cit.* pp. 111, 116, pl. xxxiii. figs. 11–14.

1860. *Byssacanthus crenulatus*, E. von Eichwald, Leth. Rossica, vol. i. p. 1598.

Type. Keyserling Collection.
The type species.
Form. & Loc. Devonian : St. Petersburg, Russia.

P. 2251. Two fragments. *Egerton Coll.*

The following species have also been described, but there are no examples in the Collection :—

Byssacanthus arcuatus, L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 111 : *Onchus arcuatus*, L. Agassiz, Poiss. Foss. vol. iii.

(1837), p. 7, pl. i. figs. 3–5.—Old Red Sandstone; Bromyard, Herefordshire. [? Cephalaspidian cornua.]

Byssacanthus gosseleti, C. Barrois, Ann. Soc. Géol. du Nord, vol. ii. (1875), p. 200, and Comptes Rendus Assoc. Franç. 1874, p. 381.—Upper Devonian; Couvin, Ardennes.

Byssacanthus lævis, L. Agassiz, Poiss. Foss. V. G. R. (1845), pp. 111, 117, pl. xxxiii. fig. 15: *Byssacanthus dilatatus*, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1598: *Byssacanthus* (*Onchus*) *dilatatus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xix. (1846), p. 288, pl. x. figs. 2, 3.—Devonian; St. Petersburg.

A spine from the Upper Silurian of the Baltic Provinces, exhibiting considerable resemblance to *Byssacanthus*, is named *Rabdacanthus truncatus*, C. H. Pander, Foss. Fische Silur. Syst. russ.-balt. Gouvernements (1856), p. 69, pl. vi. fig. 26.

The following genera also seem to belong to this group of Ichthyodorulites:—

Cyrtacanthus, J. S. Newberry (Rep. Geol. Surv. Ohio, vol. i. pt. ii. 1873, p. 306), with the single species, *C. dentatus*, Newberry, *ibid.* p. 307, pl. xxix. fig. 5. [Doubtfully assigned to *Erismacanthus* ("*Cladacanthus*") by J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 29.]—Corniferous Limestone (Lower Devonian); Delaware, Ohio. [Columbia College, New York.]

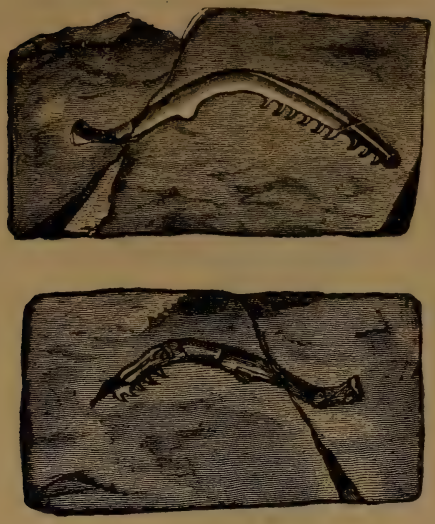
Euacanthus, H. Trautschold (Bull. Soc. Imp. Nat. Moscou, 1883, pt. ii. p. 171), with the single species, *E. margaritatus*, Trautschold, *ibid.* p. 172, pl. v. figs. 7–13.—Carboniferous Limestone; Moscow. [Trautschold Collection, Breslau.]

Harpacanthus, R. H. Traquair (Ann. Mag. Nat. Hist. [5] vol. xviii. 1886, p. 493), with the single species, *H. fimbriatus*, Traquair (*ibid.* p. 493, woodcut), previously named *Tristychius fimbriatus*, T. Stock (Ann. Mag. Nat. Hist. [5] vol. xii. 1883, p. 177, pl. vii. fig. 1).—Middle Carboniferous Limestone; Gilmerton, near Edinburgh. [Edinburgh Museum.] Also St. Louis Limestone (Lower Carboniferous); Alton, Illinois[1].

Ostracacanthus, J. W. Davis (Rep. Brit. Assoc. 1879, p. 343, and Quart. Journ. Geol. Soc. vol. xxxvi. 1880, p. 64), with the single species, *O. dilatatus*, Davis, *ibid.* 1879, p. 343, and *ibid.* 1880, p. 64, woodcut.—Cannel Coal (Middle Coal-Measures); Tingley, Yorkshire. [Collection of J. W. Davis, Esq., Halifax.]

[1] J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 203, pl. xxi. fig. 11.

Fig. 11.



Harpacanthus fimbriatus (Stock).—M. Carb. Limest., Gilmerton. (After Traquair.)

V. Dermal defences of doubtful position.

Genus **EDESTUS,** Leidy.

[Proc. Acad. Nat. Sci. Philad. vol. vii. 1856, p. 414.]

Syn. *Protopirata,* H. Trautschold, Zeitschr. deutsch. geol. Gesell. vol. xl. 1888, p. 753.

Spine broad, laterally compressed, elongated and gently arched; convex margin armed with a series of large broad denticles, serrated, and enveloped in ganoine: sides of the spine destitute of surface-ornament and ganoine, being only marked by oblique transverse sulci, each arising from the point of separation of two denticles, and often implying the complete division of the spine into a series of segments, easily detached one from another; concave margin without denticles. No distinct base of insertion.

Originally regarded as portions of the jaw of a fish by J. Leidy [1] and Newberry [2], and compared with the rostral prolongation of *Pristis* by L. Agassiz [3], these remarkable fossils were first suspected to be Elas-

[1] Proc. Acad. Nat. Sci. Philad. vol. vii. (1856), p. 414.
[2] Pal. Illinois, vol. ii. (1866), p. 84.
[3] Proc. Amer. Assoc. Adv. Sci. 1855 (1856), p. 229.

mobranch spines by Leidy[1] and definitely recognized as such by Sir Richard Owen[2]. They were also described as spines by Newberry and Worthen[3]; by Cope[4] and H. Woodward[5] the resemblance between their segmented character and that of the Cretaceous *Pelecopterus* has been pointed out; and Newberry[6] has recently

Fig. 12.

Edestus minor, Newb.—Coal-Measures, Indiana, U.S.A.

suggested that each spine may correspond to a series of spines such as occurs upon the tail of some species of *Trygon*. Trautschold[7] has revived the original hypothesis of Leidy; and Miss Hitchcock[8] compares the fossil with the intermandibular arch of the Ganoid *Onychodus*.

Edestus heinrichsi, Newberry & Worthen.

1870. *Edestus heinrichsii*, Newberry & Worthen, Pal. Illinois, vol. iv. p. 350, pl. i. fig. 1.

1879. *Edestus heinrichii*, J. S. Newberry, in Ann. Rep. Geol. Surv. Indiana, 1876–78, p. 347.

Form. & Loc. Coal-Measures: Illinois and Indiana, U.S.A.

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[1] Proc. Acad. Nat. Sci. Philad. vol. viii. (1857), p. 301.
[2] Palæontology, ed. 2 (1861), p. 123.
[3] Pal. Illinois, vol. iv. (1870), p. 350.
[4] Vert. Cret. Form. West (Rep. U.S. Geol. Surv. Territ. vol. ii. 1875), p. 244 c.
[5] Geol. Mag. [3] vol. iii. (1886), p. 6.
[6] Ann. New York Acad. Sci. vol. iv. (1888), p. 120.
[7] Bull. Soc. Imp. Nat. Moscou, 1883, pt. ii. p. 160.
[8] Amer. Nat. 1887, p. 847.

P. 3151. Plaster cast of type specimen described and figured by Newberry & Worthen, *loc. cit.*; Belleville, Illinois.
Enniskillen Coll.

P. 4795. Denticle of spine; Indiana. *Presented by Prof. Hitchcock.*

P. 2231. Smaller denticle; Indiana. *Egerton Coll.*

Edestus minor, Newberry.

1856. Figure by E. Hitchcock, Proc. Amer. Assoc. Adv. Sci. 1855, p. 229.
1861. *Edestes*, R. Owen, Palæontology, ed. 2, p. 124, woodc. fig. 38.
1866. *Edestus minor*, J. S. Newberry, Pal. Illinois, vol. ii. p. 84, pl. iv. fig. 24.
1870. *Edestus vorax*, Newberry & Worthen (*non* Leidy), *ibid.* vol. iv. pl. i. fig. 2.
1879. *Edestus minor*, J. S. Newberry, Ann. Rep. Geol. Surv. Indiana, 1876–78, p. 348.

Form. & Loc. Coal-Measures: Indiana, U.S.A.

40347. Plaster cast of specimen figured by Newberry and Worthen, *loc. cit.*, the original being preserved in the Museum of Amherst College. *Purchased*, 1867.

Edestus davisi, H. Woodward.

1886. *Edestus davisii*, H. Woodward, Geol. Mag. [3] vol. iii. p. 1. pl. i.

Form. & Loc. Carboniferous: Gascoyne District, W. Australia.

P. 5122. Plaster cast of type specimen.
Made in the Museum, 1886.

The following species have also been described, but there are no examples in the Collection:—

Edestus giganteus, J. S. Newberry, Ann. New York Acad. Sci. vol. iv. (1888), p. 121, pl. vi. fig. 1, and Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 225, pl. xli. fig. 1.—Coal-Measures; Mason Co., Illinois, U.S.A. [Columbia College, New York.]

Edestus protopirata, H. Trautschold, Nouv. Mém. Soc. Imp. Nat. Moscou, vol. xiv. (1879), p. 49, pl. vi. fig. 8, & Bull. Soc. Imp. Nat. Moscou, 1883, pt. ii. p. 169, pl. v. figs. 1, 2: *Protopirata centrodon*, H. Trautschold, Zeitschr. deutsch.

geol. Gesell. vol. xl. (1888), p. 750, woodc. of micro. sections.—Upper Carboniferous Limestone; Government of Moscow, Russia. [Trautschold Collection, Breslau. Type of *Protopirata*.]

Edestus vorax, J. Leidy, Proc. Acad. Nat. Sci. Philad. vol. vii. 1856, p. 414, and Journ. Acad. Nat. Sci. Philad. [2] vol. iii. p. 159, pl. xv.—Carboniferous; Frozen Rock, Arkansas River, Indian Territory. [Academy of Sciences, Philadelphia. The type species.]

Genus **CYNOPODIUS**, Traquair.

[Geol. Mag. [2] vol. viii. 1881, p. 35.]

Small spine-like body with a thin, expanded, spatulate exserted portion, and an extremely elongated, narrow, subcylindrical inserted portion or base. Surface of exserted portion often coated with a thin layer of ganoine, which extends for some distance down one aspect of the base; the margin of this spatulate extremity also often coarsely notched or crenulated.

Cynopodius crenulatus, Traquair.

[Plate I. fig. 4.]

1881. *Cynopodius crenulatus*, R. H. Traquair, Geol. Mag. [2] vol. viii. p. 35.

1882. *Cynopodius crenulatus*, R. H. Traquair, *loc. cit.* [2] vol. ix. p. 541.

Type. Edinburgh Museum.

Form. & Loc. Lower Carboniferous: Scottish Coalfield.

42085. Complete specimen, shown of the natural size in Pl. I. fig. 4; Calciferous Sandstone Series, Pitcorthy Shale Works, near Anstruther, Fife. *Purchased*, 1870.

P. 2263, P. 4464. Two portions of limestone with several fragments of this fossil; Calciferous Sandstone Series, Burdiehouse, near Edinburgh.

Egerton and Enniskillen Colls.

P. 2294. Complete specimen; Carboniferous Limestone (Edge-Coal Series), Loanhead, near Edinburgh.

Presented by Mrs. Burton, 1882.

P. 4498. Two specimens; Edge-Coal Series, Borough Lee, near Edinburgh. *Presented by Dr. R. H. Traquair*, 1884.

Genus **EUCTENIUS**, Traquair.

[Geol. Mag. [2] vol. viii. 1881, pp. 36, 334.]

Small dermal defence somewhat elliptical in shape, laterally compressed, convex on one side, concave on the other, with one margin nearly straight, the opposite margin evenly convex, one extremity rounded or bluntly pointed, and the other tapering to a point or produced into a long narrow extension. Convex margin divided in a comb-like manner into a series of closely arranged, acutely pointed denticles.

Fossils of this character have been assigned by Anton Fritsch to the cloacal region of certain Permian Amphibia under the name of "Kammplatten." [1]

Euctenius unilateralis (W. J. Barkas).

1869. *Ctenoptychius*, T. P. Barkas, Geol. Mag. vol. vi. p. 43, woodc. figs. 1, 2.

1873. *Ctenoptychius*, T. P. Barkas, Coal Meas. Palæont. p. 18, figs. 22, 23.

1874. *Ctenoptychius unilateralis*, W. J. Barkas, Monthly Rev. Dental Surgery, vol. ii. p. 484, figs. xvi, xvii.

1875. *Ctenoptychius unilateralis*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 220.

1881. "*Ctenoptychius*" *unilateralis*, R. H. Traquair, Geol. Mag. [2] vol. viii. p. 335.

1890. *Euctenius unilateralis*, J. Ward, Trans. N. Staffs. Inst. Mining Engineers, vol. x. p. 152, pl. ii. fig. 14.

Type. Collection of T. P. Barkas, Esq., Newcastle-upon-Tyne. The type species.

Fig. 13.

Euctenius unilateralis (Barkas).—Coal-Measures, Newcastle-upon-Tyne. The upper figure is twice, and the lower figure thrice the natural size.

Form. & Loc. Coal-Measures: Staffordshire, Northumberland, and South Scotland.

[1] Fauna der Gaskohle, vol. i. (1880), pl. xx. See also R. H. Traquair, Geol. Mag. [2] vol. viii. (1881), p. 334, and T. Stock, Ann. Mag. Nat. Hist. [5] vol. viii. (1881), p. 90.

43026. Typical specimen; Airdrie, Lanarkshire. *Purchased*, 1874.

P. 443. Broken specimen; Newsham, Newcastle-upon-Tyne. *Presented by T. P. Barkas, Esq.*, 1882.

The following species has also been described, but there are no examples in the Collection:—

Enctenius elegans, R. H. Traquair, Geol. Mag. [2] vol. viii. (1881), pp. 36, 334: '*Kammplatten*,' T. Stock, Ann. Mag. Nat. Hist. [5] vol. viii. (1881), p. 90.—Middle Carboniferous Limestone (Black-band Ironstone); Borough Lee, near Edinburgh. [R. H. Traquair Collection.]

The genus has also been recorded from the Coal-Measures of Linton, Ohio, where fine groups of this small ichthyodorulite occur. See J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 228.

A supposed Elasmobranch fish, from the Kupferschiefer of Thuringia, is also described as exhibiting several pairs of slender spines in the region of the head (C. Giebel, Zeitschr. gesammt. Naturw. 1856, p. 367, pls. iii., iv.).

Two undetermined Ichthyodorulites have been named, without description, as follows:—

Cricacanthus jonesi, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 176 (name only).—Lower Carboniferous Limestone; Armagh.

Gyropristis obliquus, L. Agassiz, *ibid.* p. 177 (name only); W. King, Permian Foss. (Pal. Soc. 1850), p. 222.—(?) Permian; Belfast.

INCERTÆ SEDIS.

Fragments of dermal armour, for the most part pertaining to unknown primitive types of fishes, from the Upper Silurian of the Island of Oesel, Baltic Sea, are described by C. H. Pander (Monographie der fossilen Fische des Silurischen Systems der russisch-baltischen Gouvernements, 1856) under the following names:—

Coccopeltus asmusi, Pander, *op. cit.* p. 50, pl. v. fig. 1.
Cyphomalepis egertoni, Pander, *ibid.* p. 51, pl. v. fig. 3.
Dasylepis keyserlingi, Pander, *ibid.* p. 54, pl. v. fig. 6.
Dictyolepis bronni, Pander, *ibid.* p. 56, pl. v. fig. 5, pl. vi. fig. 14.
Lopholepis schmidti, Pander, *ibid.* p. 55, pl. v. fig. 4.
Melittomalepis elegans, Pander, *ibid.* p. 60, pl. v. fig. 8.
Oniscolepis magna, *O. dentata*, *O. serrata*, and *O. crenulata*, Pander, *ibid.* pp. 58, 59, pl. vi. figs. 32–35.

Phlebolepis elegans, Pander, *ibid.* p. 60, pl. v. fig. 12.
Prionocanthus dubia, Pander, *ibid.* p. 70, pl. xxi. fig. 21.
Rytidolepis quenstedti, Pander, *ibid.* p. 48, pl. v. fig. 2.
Schidiosteus mustelensis, Pander, *ibid.* p. 49, pl. v. fig. 13.
Stigmolepis oweni, Pander, *ibid.* p. 53, pl. v. fig. 7.
Trachylepis formosa, Pander, *ibid.* p. 52, pl. vi. fig. 22.

The specimens described as *Coccopeltus*, *Cyphomalepis*, *Trachylepis*, and *Phlebolepis* are regarded as probably referable to Eurypterids by E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1502.

Here may also be placed the indeterminable fragments of dermal armour described under the following names :—

Chiastolepis clathrata, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. (1844), p. 831, and *ibid.* vol. xix. (1846), pt. ii. p. 301, pl. x. figs. 18, 19, and Leth. Rossica, vol. i. (1860), p. 1565, pl. lvii. fig. 11.—Devonian ; Pawlowsk, St. Petersburg. [University of St. Petersburg.]

Spirodus regularis, G. Kade, Programm k. Realschule zu Meseritz, 1858, p. 20, fig. 13.—Lower Palæozoic Boulder ; Silesia.

Osteoplax erosa, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 6, and Brit. Palæoz. Foss. (1855), p. 613, pl. iii. K. fig. 12.—Carboniferous ; Cultra, Co. Down, Ireland. [Woodwardian Museum, Cambridge.]

Sphenophorus lilleyi, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 92, pl. xx. fig. 15.—Chemung Group ; Bradford Co., Pennsylvania. [Columbia College, New York.]

Callognathus regularis, J. S. Newberry, *ibid.* p. 70, pl. xxvii. fig. 18.—Huron Shale ; Delaware, Ohio. [Columbia College, New York.]

Callognathus serratus, J. S. Newberry, *ibid.* p. 70, pl. xxvii. figs. 16, 17.—Cleveland Shale ; Lorain Co., Ohio. [Columbia College, New York.]

Family CŒLOLEPIDÆ.

Under the group of 'Cœlolepiden' Pander arranges a number of minute dermal tubercles, coated with ganoine, usually hollow within, and having the external layer separated by a constriction from the base. These tubercles consist of cosmine, and the relative size of the internal cavity varies considerably, sometimes indeed appearing to be absent.

Genus **CŒLOLEPIS**, Pander.

[Foss. Fische Silur. Syst. 1856, p. 66.]

Internal cavity of tubercle widely open at the base.

Of this genus four species are recognized, according to the form of the scale and its ornamentation. They are named *C. lævis* (p. 66, pl. iv. fig. 11, pl. vi. fig. 10), *C. schmidti* (p. 66, pl. iv. fig. 12), *C. goebeli* (p. 66, pl. iv. fig. 13), and *C. carinata* (p. 66, pl. iv. fig. 14, pl. vi. fig. 13), and each form is exhibited upon the following specimen :—

P. 6017. Small slab of shelly limestone, with numerous minute, ganoid scales; Upper Silurian, Island of Oesel.
Presented by Prof. Friedrich Schmidt, 1889.

Genus **THELODUS**, Agassiz.

[Murchison's Silur. Syst. 1839, p. 606.]

Syn. *Pachylepis*, C. H. Pander, Foss. Fische Silur. Syst. 1856, p. 67.
Thelolepis, C. H. Pander, *ibid.* p. 67.

Internal cavity of tubercle opening by a minute orifice at the base.

Thelodus parvidens, Agassiz.

1839. *Thelodus parvidens*, L. Agassiz, in Murchison's Silur. Syst. pp. 606, 704, pl. iv. figs. 34–36.
1855. *Thelodus parvidens*, F. M'Coy, Brit. Palæoz. Foss. p. 576.
(?) 1856. *Pachylepis glaber*, C. H. Pander, Foss. Fische Silur. Syst. p. 67, pl. iv. fig. 10, pl. vi. figs. 1–6, 8.
1885. *Thelodus parvidens*, F. Roemer, Palæont. Abhandl. vol. ii. p. 359, pl. xxxi. figs. 21–25.

Type. Dermal tubercles; unknown.

The type species. Tubercles not more than one millimetre in diameter, smooth and flattened, quadrate, often with rounded angles, sometimes in part fluted.

Form. & Loc. Upper Ludlow Bone-bed: Herefordshire. Upper Silurian Boulders: N.E. Germany. (?) Upper Silurian: Isle of Oesel, Baltic Sea.

P. 5099. Fragment of Upper Ludlow Bone-bed filled with the tubercles; Norton, near Onibury, Shropshire.
Presented by John Edward Lee, Esq., 1885.

A scale from the Oesel limestone, differing only from the above in the coarse crimping of two sides, is named *Pachylepis costata*, C. H. Pander, *op. cit.* p. 67, pl. vi. fig. 9.

Other dermal tubercles, apparently of the Cœlolepidæ and closely related to the above, are described thus:—

Gomphodus sandelensis, C. H. Pander, *op. cit.* (1856), p. 76, pl. vi. figs. 15–17.—Upper Silurian; Oesel.

Nostolepis striata, C. H. Pander, *ibid.* p. 68, pl. vi. fig. 7.—Ibid.

Subclass III. OSTRACODERMI.

Exoskeleton well developed, the head and anterior portion of the trunk being covered with plates; mouth destitute of hard parts. Arches for support of an appendicular skeleton rudimentary or absent. Notochord persistent.

Order I. HETEROSTRACI.

Exoskeleton consisting of calcifications without bone-corpuscles; each plate comprising three superposed layers—an inner "nacreous" layer of lamellæ, a relatively thick middle zone of polygonal cancellæ, and an outer hard layer of vaso-dentine. Dermal sense-organs well-developed, arranged in canals traversing the middle layer of the shield and opening by a double series of pores externally. Dorsal shield of few pieces, firmly united in the adult; ventral shield simple; [jaws never preserved]; orbits wide apart and laterally placed. Paired appendages absent.

In this order is included a single family, that of the Pteraspidæ.

Family PTERASPIDÆ.

External layer of each dermal shield forming an ornament of very fine, concentric, closely arranged ridges, parallel with the outer margin. Rostral region relatively small. Scales of caudal region, when present, numerous and rhomboidal.

Synopsis of Genera.

I. Orbits enclosed in dorsal shield.
Shield consisting of seven parts, fused in adult. *Pteraspis* (p. 160).
II. Orbits forming lateral notches in dorsal shield.
Shield consisting of a single plate ..... *Palæaspis* (p. 169).
Shield consisting of four parts ..... *Cyathaspis* (p. 170).

Genus **PTERASPIS**, Kner & Huxley.

[R. Kner, Haidinger's Naturw. Abhandlungen, vol. i. 1847, p. 165 ; *emend.* T. H. Huxley, Quart. Journ. Geol. Soc. vol. xvii. 1861, p. 166.]

Syn. *Palæoteuthis*, F. Roemer, Palæontogr. vol. iv. 1855, p. 72.
Archæoteuthis, F. Roemer, in Bronn's Leth. Geognostica, vol. i. 1855, p. 520.
Scaphaspis, E. R. Lankester, Rep. Brit. Assoc. 1864 (1865), Trans. Sect. p. 58 (in part).

Dorsal shield arrow-head-shaped, consisting of seven separately calcified portions :—a large *central disc*, with a triangular azygous *rostral plate* anteriorly and a large median *dorsal spine* posteriorly ;

Fig. 14.

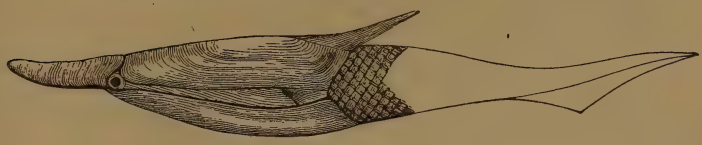
Pteraspis rostrata (Ag.).—Dorsal shield restored, after Lankester.

a pair of *orbital plates*, completely enclosing the orbit on either side and partially inserted between the rostrum and central disc ; and a

pair of postero-lateral *cornua*, each pierced with a large [? branchial] foramen. [? Pineal body occupying] a pit on the inferior aspect of the dorsal shield between the orbits. Ventral shield consisting of a single convex plate ("*Scaphaspis*"). Caudal region with small rhomboidal scales, slightly overlapping, and ornamented with few, delicate, imbricating ridges, parallel to the overlapped anterior margins.

The generic name *Pteraspis* was originally applied by Kner to the simpleshields named *Cephalaspis lewisii* and *C. lloydii* by Agassiz, in conjunction with similar fossils from Galicia, these being all regarded as not pertaining to fishes, but most nearly paralleled by the internal shell of the Cephalopod, *Sepia*. The dermal nature of the specimens and their correct reference to chordate animals was subsequently determined by Huxley [1], who altered the significance of the generic term by regarding as type the complex shield described by Agassiz as *Cephalaspis rostratus*. Huxley's determination was adopted and extended by Ray Lankester [2], who published the accompanying restoration of the dorsal shield (fig. 14), and generically separated the original type species of Kner's *Pteraspis* under the name of *Scaphaspis*. The simple shields are now proved to be the

Fig. 15.



Pteraspis rostrata (Ag.).—Side view of partially restored fish.

ventral armature of the animals covered dorsally by the more complex shields [3]; and *Scaphaspis* thus becomes in part a synonym of *Pteraspis*, as finally amended.

The anterior scales of the caudal region are known only in one specimen (No. 44116, p. 163).

[1] Quart. Journ. Geol. Soc. vol. xiv. (1858), p. 277.

[2] See especially "Fishes Old Red Sandst." pt. i. (Mon. Palæont. Soc. 1868), p. 28.

[3] A. von Alth, "Ueber die Zusammengehörigkeit der den Fischgattungen *Pteraspis*, *Cyathaspis*, und *Scaphaspis* zugeschriebenen Schilder" (Beitr. Paläont. Oesterr.-Ungarns, vol. v. 1886), p. 61, pl. xxiv.

Pteraspis rostrata (Agassiz).

[Plate IX. fig. 1.]

1835. *Cephalaspis rostratus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 148, pl. i. *b*. figs. 6, 7.

1861. *Pteraspis rostratus*, T. H. Huxley, Quart. Journ. Geol. Soc. vol. xvii. p. 165, woodc.

1865. *Pteraspis rostratus*, E. R. Lankester, Rep. Brit. Assoc. 1864, Trans. Sect. p. 58.

1868. *Pteraspis rostratus*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 32, pl. iv. figs. 1–3, 7, 8, pl. v. fig. 4, pl. vi. figs. 1–3, 6, 9, pl. vii. figs. 3, 5, 7, 9, 10, 12, 13, 19.

Type. Dorsal shield; *olim* Sir R. I. Murchison's Collection.

Rostrum obtuse, its maximum width being three quarters as great as its length, and the superior aspect marked with a longitudinal, broad flattening or shallow groove. Disc oblong, less than twice as long as broad, with parallel sides, very convex transversely, and tapering abruptly posteriorly; dorsal spine large; cornua abruptly truncated.

This is the type species and is the largest known form, the dorsal shield sometimes attaining a total length of 0·14. The ventral shield is probably described as *Scaphaspis lloydi*.

Form. & Loc. Lower Old Red Sandstone: Herefordshire, Monmouthshire, and Glamorganshire.

P. 4110–11. Two very large imperfect specimens, partly in counterpart, displaying the orbits and the pineal pit, and probably not less than 0·14 in length when complete; Great Skirrid Quarry and Gethlellydd, near Abergavenny.

Presented by Dr. D. M. McCullough, 1883.

P. 5038. Smaller splintered example; Gethlellydd.

Presented by John Edward Lee, Esq., 1885.

P. 5034–37. Shield as large as Nos. P. 4110–11, in counterpart, and three imperfect median discs of similar specimens; Goldtops, near Newport, Monmouthshire. The fourth specimen seems to show the natural form of the disc, extremely arched from side to side; its transverse section is given in the outline, Pl. IX. fig. 1.

Presented by John Edward Lee, Esq., 1885.

P. 5373. Two imperfect smaller shields, one showing the ornamentation of the rostral plate; Cradley, near Malvern.

Purchased, 1887.

P. 3242, P. 4218. Two blocks of sandstone with fragmentary shields, and an imperfect specimen, inner aspect; Cradley.
Enniskillen Coll.

P. 680–1. Anterior half of shield, and block with portions of three specimens, two showing the dorsal spine in position; Cradley. *Egerton Coll.*

43969. Well-preserved portions of disc and dorsal spine, figured by Lankester, *op. cit.* pl. vi. fig. 6; Cradley.
Purchased, 1872.

36177, 36186, 36189. Three imperfect shields, about 0·09 in length; Cradley. *Purchased*, 1861.

35978. Portion of disc and dorsal spine, inner aspect, as convex as no. P. 5037; near Ludlow. *Purchased*, 1861.

45983 a. Portion of disc and dorsal spine; Whitbatch.
Lightbody Bequest.

45963. Much fractured shield; Targrove, near Ludlow.
Lightbody Bequest.

41845. Impression of inner aspect of shield, and portion of dorsal spine; Herefordshire. *Purchased*, 1869.

P. 4112. Relatively broad, small disc, probably of this species; Pandy, near Abergavenny.
Presented by Dr. D. M. McCullough, 1883.

45961. Well-preserved fragment of disc, probably of this species; Herefordshire. *Lightbody Bequest.*

38035. Disc of a young individual, probably of this species; Heightington. *Purchased*, 1864.

42150. Similar specimen; (?) Heightington. *Baugh Coll.*

42148, 42163. Three orbital plates, either of this species or *P. crouchi*; (?) Heightington. *Baugh Coll.*

44116. Small specimen showing fragments of the anterior shields, and some of the scales of the caudal region naturally arranged; Cradley. This fossil is described and figured by E. R. Lankester in the Quart. Journ. Geol. Soc. vol. xx. (1864), p. 194, pl. xii. figs. 1–4, 6, 7, and subsequently noticed in the "Fishes Old Red Sandst." pt. i. (Pal. Soc. 1868), p. 31, pl. v. figs. 3, 5, 8, as possibly referable to *P. crouchi*. It is determined to be the dorsal portion of

the fish, showing the scar for the insertion of the spine at the hinder extremity of the shield. To the present writer, however, recent discoveries on the Continent suggest another and more probable explanation of the specimen. The scales appear to be referable to the flank, the so-called dorsal ridge-scales of Lankester not being so clearly distinguished from the other scales as indicated in the original description, and being truly referable to the middle of the flank. The supposed "scar" for the insertion of the spine seems to the present writer to be the line of separation between the dorsal and ventral shields; and a small postero-lateral portion of the dorsal shield remains above, while the greater portion of the hinder extremity of the ventral shield is preserved below. The latter exhibits the broad, longitudinal median convexity characteristic of the so-called *Scaphaspis lloydi*, and this is continued backwards by a series of calcifications which have much more the appearance of ridge-scales than those determined as such by Lankester. In this manner, the re-entering angle at the hinder margin of the armoured portion of the body is more easily explained than by the accidental crushing required in the original interpretation of the fossil. Moreover, the slight longitudinal mark on the fragment of shield bounding each margin of the supposed dorsal "scar" is paralleled by a similar mark observed near the lateral margin of several shields both of *Pteraspis* and "*Scaphaspis*," while the median portion of the inner surface of the shield is always smooth and even.

Presented by Prof. E. Ray Lankester, 1873.

The undermentioned ventral shields are probably referable to *Pteraspis rostrata*. They were described by Agassiz under the names of *Cephalaspis lewisii*[1] and *C. lloydii*[2], subsequently made the type of *Pteraspis* by Kner[3], and finally regarded as the type of *Scaphaspis* by Lankester, under the name of *S. lloydii*[4].

P. 5861. Internal cast of a fine, uncrushed specimen, 0·125 in length,

[1] Poiss. Foss. vol. ii. pt. i. (1835), p. 149, pl. i. *b*. fig. 8.

[2] *Ibid.* p. 150, pl. i. *b*. figs. 9–11.

[3] Haidinger's Naturw. Abhandl. vol. i. (1847), p. 159, pl. v.

[4] E. R. Lankester, Rep. Brit. Assoc. 1864, Trans. Sect. p. 58, and Fishes Old Red Sandst. pt. i. (Pal. Soc. 1868), p. 20, pl. i., pl. vii. figs. 1, 6, 17, 18. A shield, wanting the posterior extremity, from the Upper Silurian of Iwanie, Galicia, is assigned to this "species" by A. von Alth. Abhandl. k. k. geol. Reichsanst. vol. vii. pt. i. (1874), p. 49, pl. ii. fig. 2.

shown of two-thirds the natural size in Pl. IX. fig. 2, and employed in the woodcut-restoration, fig. 15 (p. 161); Kentchurch Hill, near Pontrilas, Herefordshire. This is apparently the only uncrushed specimen in the collection, and, as shown by the figures, proves the diagrammatic longitudinal section of '*Scaphaspis lloydii*' of Lankester (*op. cit.* pl. vii. fig. 15) to be too much arched posteriorly, while the published transverse section (*ibid.* fig. 18) applies only to the hinder third of the shield.

Presented by J. F. Symonds, Esq., 1889.

46565-66. Two imperfect specimens, about 0·09 in length, the first showing some well-preserved fragments of the shield itself; Cradley. *Purchased*, 1875.

46875. Similar shield, in counterpart; Cradley. *Purchased*, 1875.

P. 682. Anterior half of shield, inner aspect; probably from Cradley. *Egerton Coll.*

P. 4218 a. Small shield, inner aspect, probably from Cradley. *Enniskillen Coll.*

P. 4103, P. 4113–14. Two small specimens, and the anterior half of a third, apparently in the same matrix as the small dorsal shield, No. P. 5038; Gethlellyd, near Abergavenny. *Presented by Dr. D. M. McCullough*, 1883.

P. 4105, P. 4105 a. Three detached specimens, and one imperfect example associated with part of a median dorsal disc of *Pteraspis*; Pandy, near Abergavenny. *Presented by Dr. D. M. McCullough*, 1883.

45960. Typical specimen, 0·07 in length; Abergavenny. *Lightbody Bequest.*

P. 5039. Imperfect shield, 0·1 in length; Star Pitch. *Presented by John Edward Lee, Esq.*, 1885.

P. 5041. Imperfect shield, inner aspect; Newbridge, Glamorganshire. *Presented by John Edward Lee, Esq.*, 1885.

P. 5046. Imperfect cast of shield, 0·05 in length; Newport, Monmouthshire. *Presented by John Edward Lee, Esq.*, 1885.

45950. Well-preserved specimen, figured by Lankester, *op. cit.* pl. i. fig. 8; Hayton's Bent, near Ludlow. *Lightbody Bequest.*

45950 a. More imperfectly preserved shield, apparently from the same horizon and locality. *Lightbody Bequest.*

45955. Internal cast and fragments of small shield; Downton Hall, near Ludlow. *Lightbody Bequest.*

P. 3245. Internal cast and fragments of small shield; Leominster. *Enniskillen Coll.*

42153. Crushed and broken specimen; locality unknown. *Baugh Coll.*

46876. Internal cast of very broad, flattened specimen, doubtfully of this species; Cradley. *Purchased*, 1875.

P. 193. Anterior two-thirds of similar specimen; Heightington. *Weaver-Jones Coll.*

42159–60. Three very small shields, doubtfully of this species; near Trimpley, Worcestershire. *Baugh Coll.*

38034. Two similar, but somewhat larger, shields, associated, and showing portions of the external surface; Trimpley. *Purchased*, 1864.

An imperfectly known species, of large size, apparently closely related to *Pteraspis rostrata*, has been obtained from the uppermost Silurian and Lower Devonian of Galicia, and described under the name of *Pteraspis major*, A. von Alth, Abhandl. k. k. geol. Reichsanstalt, Wien, vol. vii. pt. i. (1874), p. 44, pl. i. figs. 1–4, pl. iii. figs. 3–5 [1]. The following specimen may be referable to this form:—

P. 6099. Portions of dorsal and ventral shields in natural apposition, the dorsal showing the posterior spine; Upper Ludlow, Bilcze-on-Sered, Galicia. *From the Alth Collection.—Presented by Prof. W. Szajnocha*, 1888.

It is interesting to note that the supposed ventral shield of *P. rostrata* has already been recorded by v. Alth from the Upper Silurian of Galicia (*supra*, p. 164, footnote).

[1] If the undetermined specimen described and figured in Alth's memoir (p. 71, pl. v. fig. 33) pertain to this species, as suggested, the broad, rounded character of the rostra region suffices to distinguish it from *P. rostrata*.

Pteraspis crouchi, Lankester.

1865. *Pteraspis crouchii*, E. R. Lankester (*ex* Salter, MS.), Rep. Brit. Assoc. 1864, Trans. Sect. p. 58.

1868. *Pteraspis crouchii*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 30, pl. iii., pl. iv. fig. 5, pl. vi. figs. 4, 7, 8, pl. vii. figs. 4, 8, 11.

1887. *Pteraspis crouchii*, A. S. Woodward, Proc. Zool. Soc. p. 478, woodc.

Type. Dorsal shields; British Museum, Ludlow and Oxford Museums.

Rostrum slender and acutely pointed, upwardly curved, its maximum width being about half as great as its length. Disk oblong, heart-shaped, abruptly tapering posteriorly; dorsal spine large; cornua large and broad, obtusely pointed.

This is a smaller species than *P. rostrata*, and its ventral shield is probably described as *Scaphaspis recta*.

Form. & Loc. Lower Old Red Sandstone (Cornstones): Whitbatch and Ludlow, Herefordshire, and Abergavenny, Monmouthshire.

33317 a, b. Two imperfect median discs; Ludlow. *Purchased*, 1858.

45954, 45956. Two imperfect discs, one with fragments of the spine; Downton Hall. *Lightbody Bequest.*

P. 3246. Internal cast and fragments of disc; near Ludlow. *Enniskillen Coll.*

45941–42. Two portions of rostrum figured by Lankester, *op. cit.* pl. iii. figs. 12, 13; Leyster's Pole. *Lightbody Bequest.*

45967. Imperfect rostrum, dorsal aspect, figured *ibid.* pl. vi. fig. 7; Short Wood, near Ludlow. *Lightbody Bequest.*

45951, 45965. Fractured rostrum from Hayton's Bent, and a fragment from Downton Hall. *Lightbody Bequest.*

42163. Imperfect disc, doubtfully of this species; Herefordshire. The specimen shows the sensory canals injected with mineral matter, and is described and figured by the present writer, *loc. cit.*, the figure being reproduced in the accompanying woodcut (fig. 16). *Baugh Coll.*

The undermentioned ventral shields are probably referable to

Pteraspis crouchi. They are described under the name of *Scaphaspis rectus*, Lankester[1], and are relatively longer and narrower than the shields named *S. lloydi*, with more nearly parallel sides.

Fig. 16.

Pteraspis crouchi, Lank.—Portion of shield, dorsal aspect, showing sensory canals. [No. 42163.] From Proc. Zool. Soc. 1887.

37389. Imperfect specimen associated with a fragment of the shield of *Phlyctænaspis*; Heightington. *Purchased*, 1863.

42149–50. Four imperfect specimens; Heightington. *Baugh Coll.*

38034 a. Internal cast of shield, figured by Lankester, *op. cit.* pl. ii. fig. 7; Worcestershire. *Purchased*, 1864.

P. 4107–8. Two specimens; Asylum Quarry, Abergavenny. *Presented by Dr. D. M. McCullough*, 1883.

P. 4109. Internal cast of small shield; from boulder in railway-cutting, Maincliff, Abergavenny. *Presented by Dr. D. M. McCullough*, 1883.

The following species of *Pteraspis* have also been described, but there are no examples in the Collection:—

Pteraspis angustata, A. von Alth, Abhandl. k. k. geol. Reichsanst. vol. vii. pt. i. (1874), p. 45, pl. i. fig. 11, pl. iii. figs. 6, 7.—Lower Devonian; Iwanie and Kriszczatek, Galicia. [Imperfect shields.]

Pteraspis mitchelli, J. Powrie, Geologist, vol. vii. (1864), p. 172; E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.

[1] Fishes Old Red Sandst. pt. i. (Pal. Soc. 1868), p. 23, pl. ii. figs. 5–8, 12, 13, pl. vii. fig. 2.

1868), p. 33, pl. v. figs. 1, 2, 6, 10, 11: *Pteraspis*, H. Mitchell, Geologist, vol. vii. (1864), p. 117, woodc.—Lower Old Red Sandstone; Forfarshire. [Internal cast of shield; Dundee Museum.]

Pteraspis podolica, A. von Alth, *loc. cit.* p. 42, pl. i. figs. 5–10, pl. ii. fig. 1.—Upper Ludlow; Zaleszczyki, Kriszczatek, and Dobrowlany, Galicia. [Shields, wanting rostrum, but with relatively large cornua.

Pteraspis rhenana, C. Schlüter, Sitzungsb. niederrhein. Ges., Bonn, 1887, p. 125.—Lower Devonian; near Bonn. [Portion of median disc; University of Bonn.]

The impression of the inner aspect of an imperfect median disc of *Pteraspis* from the Upper Silurian (or Lower Devonian) of Galicia is named "*Pterichthys*?" by R. Kner, Haidinger's Naturw. Abhandl. vol. i. (1847), p. 167, pl. v. fig. 3: see also *Scaphaspis kneri*, p. 174.

Genus **PALÆASPIS**, Claypole.

[Amer. Naturalist, vol. xviii. 1884, p. 1224.]

Syn. *Holaspis*, E. R. Lankester (*non* J. E. Gray, 1863), Geol. Mag. vol. x. 1873, p. 242.
Scaphaspis, E. R. Lankester, Rep. Brit. Assoc. 1864 (1865), Trans. Sect. p. 58 (in part).

Dorsal shield resembling that of *Pteraspis* in form, but apparently consisting of a single plate and destitute of a median dorsal spine. Orbits forming notches in the shield at the base of the rostrum, not completely enclosed.

This genus was first defined by Lankester under the preoccupied name of *Holaspis*, and the type species is *P. sericea*.

Palæaspis sericea (Lankester).

1873. *Holaspis sericeus*, E. R. Lankester, Geol. Mag. vol. x. pp. 241, 331, pl. x. and woodc.

Type. Dorsal shield; British Museum.

Shield narrow and elongated, the rostral region sharply rounded and much broader than long; lateral margins, when uncrushed, apparently bulging outwards immediately behind the orbits, nearly parallel in the hinder half; posterior margin angulated mesially.

Form. & Loc. Lower Old Red Sandstone (Cornstones): Abergavenny, Monmouthshire.

P. 4117. Type specimen described and figured by Lankester, *loc. cit.* *Presented by Dr. D. M. McCullough*, 1883.

Palæaspis americana, Claypole.

1884. *Palæaspis americana* (? and *P. bitruncata*), E. W. Claypole, Amer. Naturalist, vol. xviii. p. 1224.
1885. *Palæaspis americana*, E. W. Claypole, Quart. Journ. Geol. Soc. vol. xli. p. 62, woodc. fig. 7.
(?) 1885. *Palæaspis bitruncata*, E. W. Claypole, *ibid.* p. 62, woodc. fig. 8.

Type. Imperfect dorsal shield ; Museum of Buchtel College, Akron, Ohio.

A species known only from imperfect specimens, as yet incapable of precise definition, but apparently distinguished from *P. sericea* by the more regularly ovate form of the shield and the slightly more obtuse rostrum.

The form named *bitruncata* is not improbably the ventral shield of this species.

Form. & Loc. Onondaga Group : Perry Co., Pennsylvania.

P. 6132. Imperfect internal cast of shield.
Presented by Prof. E. W. Claypole, 1890.

P. 6133. Several fragments.
Presented by Prof. E. W. Claypole, 1890.

Genus **CYATHASPIS**, Lankester.

[Rep. Brit. Assoc. 1864 (1865), Trans. Sect. p. 58.]

Syn. *Diplaspis*, G. F. Matthew, Bull. Nat. Hist. Soc. New Brunswick, no. vi. 1887, p. 69.
Scaphaspis, E. R. Lankester, Rep. Brit. Assoc. 1864 (1865), Trans. Sect. p. 58 (in part).

Dorsal shield oval, consisting of four separately calcified portions —a large *central disc*, with a short azygous *rostral plate* anteriorly, and a pair of large *cornua* on the sides. Orbits not completely enclosed in the shield.

In the so-called *Diplaspis*, and in *Cyathaspis integer*, the dorsal and ventral shields have been found in natural association ; and a *Scaphaspis*-shaped shield occurs in the same beds as the type species. Until confirmatory evidence is obtained, we venture to regard the transverse division of the lateral cornua in *Diplaspis* as accidental.

Cyathaspis banksi (Huxley & Salter).

[Plate IX. fig. 3.]

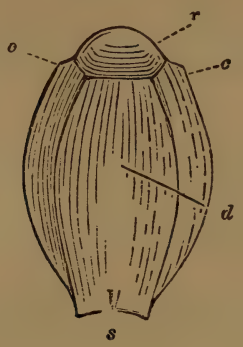
1856. *Pteraspis banksii*, Huxley & Salter, Quart. Journ. Geol. Soc. vol. xii. p. 100, pl. ii. fig. 2.

1858. *Pteraspis banksii*, T. H. Huxley, *ibid.* vol. xiv. p. 274, pl. xv.
1865. *Cyathaspis banksii*, E. R. Lankester, Rep. Brit. Assoc. 1864, Trans. Sect. p. 58.
1868. *Cyathaspis banksii*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.) p. 26, pl. ii. figs. 9–11, pl. iv. fig 6.

Type. Dorsal shield; unknown.

The type species, the dorsal shield attaining a length of about 0·05. Median disc oblong, strongly arched from side to side, truncated posteriorly, with a very small median spine; rostrum very short and broad; lateral cornua extending from the orbits back-

Fig. 17.



Outline of dorsal shield of *Cyathaspis*, restored by Lankester.
c., cornua; *d.*, median disc; *o.*, orbit; *r.*, rostral plate; *s.*, dorsal spine.

wards, broadest mesially, tapering behind, and not projecting beyond the posterior margin of the disc. Superficial striæ fine, those of the rostrum transverse, the others longitudinal, and those of the disc partially subdivided into groups by irregular longitudinal costæ.

Form. & Loc. Upper Ludlow and Downton Sandstone: Herefordshire.

45939. Small slab of Downton Sandstone, with casts of four imperfect shields, one figured by Lankester, *op. cit.* pl. iv. fig. 6; Bradnor Hill, Kington. *Lightbody Bequest.*

P. 684, P. 683. Ferruginous fossil shield, showing the coarse longitudinal costæ of the disc with intervening fine striæ; also a cast of the inner aspect of part of a similar specimen displaying some of the supposed branchial excavations and the pineal pit; Downton Sandstone, Kington.
Egerton Coll.

P. 3240. Two typical specimens preserved in ferruginous matter; Kington. *Enniskillen Coll.*

P. 3241. Well-preserved fragments of an apparently uncrushed shield, the ornamentation of part of the disc being shown, of twice the natural size, in Pl. IX. fig. 3; Upper Silurian Bone-bed, Martel, near Ledbury. *Enniskillen Coll.*

The so-called *Scaphaspis truncatus*[1] or *Pteraspis truncatus*[2] appears to the present writer to be founded in part upon the detached median discs of *Cyathaspis banksi*, and in part upon ventral shields that may probably be referred to this species. The following are specimens of this character:—

P. 683 a. Shield preserved in ferruginous matter, and the anterior half of a similar specimen; Downton Sandstone, Kington. *Egerton Coll.*

P. 3243. A complete, apparently uncrushed specimen, similarly preserved; Kington. *Enniskillen Coll.*

42158. Impression of shield showing ornament; locality unknown. *Baugh Coll.*

P. 3244. Well-preserved fragment of shield, perhaps of this species; Ludlow Bone-bed, Ludford Lane, Ludlow. *Enniskillen Coll.*

Cyathaspis macculloughi, sp. nov.

[Plate IX. fig. 4.]

Type. Imperfect dorsal shield: British Museum.

Median disc oblong, relatively narrow; rostrum very short and broad; lateral cornua extending from the orbits backwards, broadest mesially. Superficial striæ relatively coarse, those of the disc uniform and not interrupted with longitudinal costæ.

Form. & Loc. Lower Old Red Sandstone: Herefordshire.

P. 4797. The type specimen, shown, of the natural size, in Pl. IX. fig. 4; England's Hill Quarry, Bodenham. A large portion of the shield is preserved, being exposed from the

[1] E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc. 1868), p. 24, pl. ii. figs. 1–3.

[2] Huxley & Salter, Quart. Journ. Geol. Soc. vol. xii. (1856), p. 100, pl. ii. fig. 1.

inner aspect; and parts of the ornamented external surface are also seen in impression. The pineal pit and the pair of >-shaped depressions on the inner face of the shield immediately behind are conspicuous.

Presented by Sir Richard Owen, K.C.B., 1884.

The following species of *Cyathaspis* have also been described, but there are no examples in the Collection :—

Cyathaspis acadica: *Pteraspis acadica*, G. F. Matthew, Canadian Record of Science, vol. ii. (1886), p. 251: *Diplaspis acadica*, G. F. Matthew, Bull. Nat. Hist. Soc. New Brunswick, no. vi. (1887), p. 69, woodc., and Trans. Roy. Soc. Canada, vol. vi. sect. iv. (1888), p. 49, pl. iv. figs. 1–4.—Upper Silurian (Division 2); Westfield, New Brunswick. [The type species of *Diplaspis*.]

Cyathaspis integer, A. Kunth, Zeitschr. deutsch. geol. Ges. vol. xxiv. (1872), p. 7, pl. i. figs. 1–6; Jentzsch, *ibid.* vol. xxxi. (1879), p. 793; F. Roemer, Palæont. Abhandl. vol. ii. (1885), p. 378, pl. xxxiii. fig. 1.—Upper Silurian (erratic block); Schöneberg, near Berlin, and Bromberg. [Berlin University Museum.]

(?) *Cyathaspis schmidti*, F. E. Geinitz, Zeitschr. deutsch. geol. Ges. vol. xxxvi. (1884), p. 857, pl. xxx.; F. Roemer, Palæont. Abhandl. vol. ii. (1885), p. 379.—Upper Silurian; Rostock. [Rostock University Museum.] [? *Palæaspis*.]

Cyathaspis sturi, A. von Alth, Abhandl. k. k. geol. Reichsanst. vol. vii. no. 1 (1874), p. 46, pl. v. figs. 1–3.—Upper Silurian; between Doroschoutz and Wasileu, on the Dniester, Galicia. [Dorsal shield; Imperial Geol. Survey, Vienna.]

(?) *Cyathaspis symondsi*, E. R. Lankester, Rep. Brit. Assoc. 1864, Trans. Sect. p. 58, and Fishes Old Red Sandst. pt. i. (Pal. Soc. 1868), p. 27, pl. vi. fig. 5.—Lower Old Red Sandstone (Cornstones); Herefordshire. [Internal cast of dorsal shield; Museum of Practical Geology.]

To *Cyathaspis* may also probably be referred the ventral shields described as follows :—

Scaphaspis ludensis, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc. 1868), p. 25, pl. ii. fig. 4: *Pteraspis ludensis*, J. W. Salter, Ann. Mag. Nat. Hist. [3] vol. iv. (1859), p. 45, woodc. fig. 1.—Lower Ludlow; Church Hill, Leintwardine. Upper Ludlow; near Ludlow. [Shield; Mus. Pract. Geol.]

Several ventral shields of Pteraspidians, not hitherto generically determined, have received the names mentioned below. The majority are probably referable to *Pteraspis*, and of the first the specimen described by Roemer in 1858 is preserved in the Collection (**36047**. *Purchased*, 1861).

Scaphaspis dunensis, E. R. Lankester, Fishes Old Red Sandst. pt. i. (1868), p. 20, woodc. fig. 10: *Pteraspis dunensis*, T. H. Huxley, Quart. Journ. Geol. Soc. vol. xvii. (1861), p. 163: *Palæoteuthis dunensis*, F. Roemer, Zeitschr. deutsch. geol. Ges. vol. vi. (1854) p. 650, and Palæontographica, vol. iv. (1855), p. 72, pl. xiii.: *Archæoteuthis dunensis*, F. Roemer, in Bronn's Leth. Geognost. (1855), p. 520, and Neues Jahrb. 1858, p. 55: ? *Scaphaspis bonnensis*, C. Schlüter, Sitzungsb. niederrhein. Ges. Bonn, 1887, p. 125. [Imperfect shield; University of Bonn.]—Lower Devonian; Eifel. [Imperfect shield, wanting external layer.]

Scaphaspis elongata, A. von Alth, Abhandl. k. k. geol. Reichsanst. vol. vii. no. 1 (1874), p. 51, pl. ii. fig. 4.—Upper Silurian (red sandstone); Wojskie, Galicia.

Scaphaspis haueri, A. von Alth, *ibid.* p. 50, pl. iv. figs. 6, 7.—Upper Silurian and Lower Devonian; Iwanie, Galicia. [Imperial Geol. Survey, Vienna.]

Scaphaspis kneri, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc. 1868), pp. 2, 19, 20, woodc. fig. 9, and Geol. Mag. vol. vii. 1870, p. 398; A. von Alth, Abhandl. k. k. geol. Reichsanst. vol. vii. no. 1 (1874), pp. 48, 75, pl. ii. figs. 3, 5, 7, 8: *Pteraspis* sp., R. Kner, Haidinger's Naturw. Abhandl. vol. i. (1847), p. 160, pl. v. figs. 1, 2 (?4): *Palæoteuthis kneri*, E. von Eichwald, Analecta Zool. u. Palaeont. Russlands (1871), p. 5: *Pteraspis kneri*, A. Kunth, Zeitschr. deutsch. geol. Ges. vol. xxiv. (1872), p. 7; F. Schmidt, Verhandl. russ.-kais. mineral. Ges. St. Petersburg, [2] vol. viii. (1873), pl. v. figs. 1–8 (doubtfully assigns to this species portions of the dorsal shield of a typical *Pteraspis*, compared with *P. crouchi* by E. R. Lankester, Geol. Mag. [2] vol. i. 1874, p. 288).—Upper Silurian; Galicia. [Imperial Museum, Vienna.]

Scaphaspis nathorsti, E. R. Lankester, Kongl. Svenska Vetensk.-Akad. Handl. vol. xx. no. 9 (1884), p. 5, pl. i. figs. 1–3.—Lower Devonian; Dickson Bay, Spitzbergen. [Royal State Museum, Stockholm.]

Scaphaspis obovata, A. von Alth, Abhandl. k. k. geol. Reichsanst. vol. vii. no. 1 (1874), p. 51, pl. iii. fig. 1.—Upper Silurian; Dobrowlany, Galicia.

Scaphaspis radiata, A. von Alth, *ibid.* p. 50, pl. ii. fig. 6.—Upper Silurian; Zaleszczyki, Galicia.

Fragments of Pteraspidian shields, not sufficiently complete for precise generic determination, are met with in the Lower Devonian of Cornwall, and were originally described as fossil sponges by M'Coy, under the name of *Steganodictyum cornubicum*[1]. Their fish-like character was first noted by C. W. Peach[2], who collected many specimens; they were subsequently assigned to *Pteraspis* by J. W. Salter[3], and finally named *Scaphaspis cornubicus* by E. R. Lankester and H. Woodward[4], and J. E. Lee. Numerous fragments from Polperro are preserved in the Lee Collection, and the following is a larger specimen:—

38570 (Invertebrate Register). Small slab with portions of a shield showing the external striated surface and the middle cancellated layer; Fowey. *Purchased*, 1858.

According to F. Schmidt (Verhandl. russ.-kais. mineral. Ges. [2] vol. viii. 1873, p. 136, pl. v. figs. 9, 10), the so-called *Palæoteuthis marginalis*, E. von Eichwald (Analect. Zool. u. Palaeont. Russlands, 1871, p. 5, pl. i. fig. 12), from the Petchora, is a doubtful Pteraspidian; and to the same family may probably be referred the genus and species, *Tolypelepis undulatus*, C. H. Pander (Foss. Fische Silur. Syst. 1856, p. 61, pl. vi. fig. 24), founded upon a fragment of dermal plate from the Upper Silurian of Ohhesaar, Isle of Oesel.

Fragments of dermal plates, perhaps referable to Pteraspidians, and consisting of numerous, irregular, closely arranged, narrow shining scales, are met with in the Lower Old Red Sandstone of Herefordshire, and named *Kallostrakon podura*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc. 1870), p. 61, pl. xiii. figs. 20, 21, pl. xiv. fig. 6. [Oxford Museum.] The following are specimens of this character:—

45980. Several fragments, varying in coarseness; Lower Old Red Sandstone, Bush Pitch, Ledbury. *Lightbody Bequest.*

[1] F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. viii. (1851), p. 481, and Brit. Palæoz. Foss. (1851), pl. ii. A. figs. 1–3.

[2] C. W. Peach, Rep. Brit. Assoc. 1843 (1844), Trans. Sect. p. 56.

[3] J. W. Salter, in Wyatt-Edgell, Geol. Mag. vol. v. (1868), p. 247.

[4] E. R. Lankester and H. Woodward, Geol. Mag. vol. v. (1868), p. 248; J. E. Lee, *ibid.* [2] vol. ix. (1882), p. 105, pl. iii. figs. 2, 3.

P. 2253, P. 2255. Two specimens, one in the form of a thick quadrate plate; Bush Pitch. *Egerton Coll.*

P. 4478. Several fragments; Bush Pitch. *Enniskillen Coll.*

P. 5087. Coarse fragment; Bush Pitch.
Presented by John Edward Lee, Esq., 1885.

Order II. OSTEOSTRACI.

Exoskeleton consisting of calcifications, partly with bone-corpuscles; each plate comprising three superposed layers, the middle layer solid, with a coarse reticulation of large vascular canals. Dermal sense-organs leaving no impressions upon the exoskeleton. Dorsal shield consisting of one principal piece, sometimes with a separate mesial piece or fused body-scales posteriorly; orbits close together. Ventral shield simple, or replaced by polygonal calcifications. [Jaws never preserved.] Paired fins absent.

Synopsis of Families.

Surface of shield tuberculated; interorbital piece fixed ..... CEPHALASPIDÆ (p. 176).
Surface of shield finely punctate; interorbital piece loose ..... TREMATASPIDÆ (p. 201).

Family CEPHALASPIDÆ.

Shield rounded or tapering in front, abruptly truncated behind; interorbital piece firmly fixed; ornamentation consisting of more or less numerous tuberculations. [The middle layer of the shield sometimes produced postero-laterally into a pair of flexible expansions (? opercula).] Dorso-lateral squamation consisting of series of very deep and narrow, imbricating scales.

Synopsis of Genera.

I. Anterior dorsal body-scales not fused into a continuous plate.
Postero-lateral angles of shield produced into acute cornua not exceeding the shield in length ..... *Cephalaspis* (p. 177).

Postero-lateral cornua exceeding the shield in length ..... *Eukeraspis* (p. 193).

II. Anterior dorsal body-scales fused into a continuous plate.

Cornua divergent; shield larger than the dorsal plate ..... *Auchenaspis* (p. 195).

Cornua rudimentary and bordering the dorsal plate, which is larger than the shield.... *Didymaspis* (p. 199).

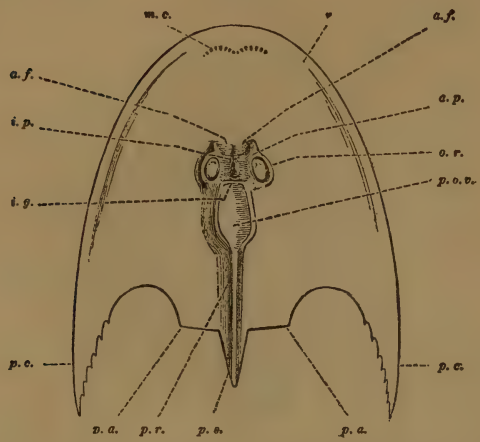
Genus **CEPHALASPIS**, Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1835, p. 135.]

Syn. *Eucephalaspis*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc. 1870), p. 43.
Hemicyclaspis, E. R. Lankester, *ibid.* p. 43.
Zenaspis, E. R. Lankester, *ibid.* p. 43.

Postero-lateral angles of shield more or less produced into acute cornua, not exceeding the shield in length. Body elevated, and triangular in transverse section. Flank-scales in three series, the

Fig. 18.



Cephalaspis lyelli, Ag.—Outline sketch of shield, restored by Lankester. *a. f.*, antorbital fossæ; *a. p.*, antorbital prominences; *i. g.*, interorbital ridge or groove; *i. p.*, interorbital prominence; *o. r.*, orbital rim; *m. c.*, marginal cells; *p. o. v.*, postorbital valley; *p. a.*, posterior angle; *p. c.*, posterior cornu; *p. r.*, posterior ridge; *p. s.*, posterior spine; *r.*, rim.

upper series of each side meeting in the mesial line above, the middle series deepest, and the lowermost forming an infero-lateral fringe often serrated; ventral scales apparently small, arranged in **V**-shaped

transverse rows equal in number to the series of flank-scales. Scales immediately behind the anterior shield not fused together or represented by a broad plate.

The shield of this genus has been described in detail by Huxley and Lankester, and the accompanying figures (figs. 18–20) are copied from the latter author. Fig. 18 shows the dorsal contour of the shield, with its parts indicated by the lettering. The several prominences of the hinder border are the lateral cornua (*p. c.*), the median spine (*p. s.*), and the broad median production of the shield, with its sharp angles (*p. a.*). Each orbit has a surrounding rim (*o. r.*), extended in front into a small antorbital prominence (*a. p.*); and between the eyes is an elongated interorbital prominence (*i. p.*), evidently hollow, and homologous with the pit in the pineal plate of the Antiarcha (see p. 210). Immediately in advance of the latter on the under surface of the shield is a small, short, narrow median septum. Between the antorbital prominences and this septum is the pair of small antorbital fossæ (*a. f.*) exposed only when the substance of the shield is removed; and another great superficial fossa (*p. o. v.*) extends from a ridge or groove (*i. g.*) joining the hinder borders of the orbits to the origin of the median ridge (*p. r.*) which

Fig. 19.

Cephalaspis.—Diagram of inferior aspect of shield, showing inferior rim; after Lankester.

terminates in the posterior spine. Inexplicable concavities immediately beneath the cranial roof near the rostrum are named marginal cells (*m. c.*), these being more extensively developed round the rim in *Eukeraspis* (fig. 27, p. 194); and when the fossil is so preserved as to show the contour of some of the originally soft parts, the cast of a

pair of great rounded lobes, meeting in the middle line, is conspicuous in advance of the orbital region. As shown from beneath (fig. 19), the margin of the shield is reflexed inwards to form a flattened and ornamented inferior rim, wider behind than in front; and, as proved by transverse sections (fig. 20), the inner border of

Fig. 20.

Cephalaspis.—Transverse section of shield, after Lankester.
i, inferior lamina; *m*, margin; *s*, superior lamina.

this rim is continued upwards into a delicate smooth lamina of calcified tissue (*i.*), which lies beneath the outer or superior lamina (*s.*) of the shield proper.

Cephalaspis lyelli, Agassiz.

1835. *Cephalaspis lyellii*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 142, pl. i. *a.* fig. 2 (*non* fig. 1), pl. i. *b.* figs. 3, 4 (*non* figs. 1, 2, ? 5).
1839. *Cephalaspis lyellii*, R. I. Murchison, Silur. System, p. 589, pl. i. figs. 2, 3 (*non* fig. 1).
1870. *Eucephalaspis lyellii*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 43, pl. viii. fig. 1, pl. xi. figs. 1, 2.
1870. *Eucephalaspis agassizii*, E. R. Lankester, *ibid.* p. 46, pl. ix. figs. 2, 3, 6, and woodc. fig. 18.

Type. Head and trunk, wanting fins; British Museum.

The type species, of moderate size. Shield sharply rounded or obtusely pointed in front; orbits placed nearly midway between the anterior and posterior margins; cornua well developed, broad, and acutely pointed. Superficial tuberculations relatively small, closely and irregularly arranged. Scaly trunk about two and a half times as long as the shield.

Form. & Loc. Lower Old Red Sandstone: Forfarshire, Herefordshire, Monmouthshire, and Worcestershire.

The English shields originally placed by Agassiz in *C. lyelli* were separated from this species by E. R. Lankester under the name of *C. agassizi*, from the circumstance that "the orbits in the Scotch specimens are placed more posteriorly in the shield, and the cornua

are less produced and less divergent than in the English heads." A Glammis specimen mentioned below (No. P. 3234) apparently rendering this conclusion unjustifiable, we venture to revert to Agassiz's

Fig. 21.

Cephalaspis lyelli, Ag.—Side view, restored by Lankester. [The opercular fold is too distinctly separated from the shield, having the appearance of a pectoral appendage.]

original arrangement, and regard the differences as due to accident in preservation.

20087. Type specimen, described and figured by Agassiz (p. 143, pl. i. *a*. fig. 2) and Lankester (p. 44, pl. viii. fig. 1); Glammis, Forfarshire. Since the original description of the specimen by Agassiz, the squamation of the caudal region has been more completely extricated from the matrix; and during this process the greater part of the opercular fold of each side was accidentally destroyed.
Presented by Sir Charles Lyell, Bart., 1846.

P. 3233. Portions of head and trunk of a similar specimen; Glammis.
Enniskillen Coll.

P. 3234. Small shield, much crushed and broken, labelled *C. agassizi* by Mr. William Davies, and agreeing in every respect with the definition of this supposed distinct species; Glammis. The portion of shield in advance of the anterior margin of the orbits measures 0·015 in length, that behind 0·02.
Enniskillen Coll.

42140. Fragments and internal impression of shield; Cradley, Herefordshire. *Baugh Coll.*

P. 3235. Small shield, scarcely crushed, but wanting the external layers; Cradley. *Enniskillen Coll.*

36052. Portion of a similar specimen; Cradley or Ludlow.
Purchased, 1861.

45945–47, 47 a. Four imperfect shields; Whitbatch, near Ludlow
Lightbody Bequest.

P. 672. Flattened imperfect specimen; Downton, near Ludlow. *Egerton Coll.*

P. 5048. Partially crushed and broken shield, wanting right cornu; Downton. *Presented by John Edward Lee, Esq.*, 1885.

P. 4115. Small crushed shield, wanting the external layers and showing the orbits placed as far backwards as in the type specimen; Abergavenny. *Presented by Dr. D. M. McCullough*, 1883.

42142. A very small shield, in counterpart, probably young of this species; Heightington. *Baugh Coll.*

46568-69, 46877-78. Four very small, much crushed shields, doubtfully referable to young of this species; Cradley. *Purchased*, 1875.

37388. Middle portion of shield either of this species or of *C. salweyi*; Heightington. *Purchased*, 1863.

Cephalaspis salweyi, Egerton.

1857. *Cephalaspis salweyi*, Sir P. Egerton, Quart. Journ. Geol. Soc vol. xiii. p. 283, pl. x. fig. 1.
1859. *Cephalaspis asterolepis*, R. Harley, Quart. Journ. Geol. Soc. vol. xv. p. 503.
1859. *Cephalaspis salweyi*, R. Harley, *ibid.* p. 504.
1868. *Cephalaspis asterolepis*, J. W. Salter, Proc. Woolhope Nat. Field Club, p. 240, and frontispiece.
1870. *Zenaspis salweyi*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 52, pl. xii. figs. 2, 5, 6 (*non* pl. viii. figs. 2–4), woodc. figs. 26, 28 (*non* fig. 27).
1881. *Cephalaspis asterolepis*, H. Woodward, Geol. Mag. [2] vol. viii. p. 193, pl. vi.

Type. Middle portion of shield; Ludlow Museum.

The largest known species, the shield sometimes attaining a total length of 0·18. Shield sharply rounded in front; orbits placed nearly midway between the anterior and posterior margins; cornua well developed, slender, and acutely pointed. Superficial tuberculations relatively large, sparsely and irregularly arranged.

The detached tuberculated plates, doubtfully assigned to this species by Lankester, are truly referable to Coccostean fishes (see *Phlyctænaspis anglica*, p. 296).

Form. & Loc. Lower Old Red Sandstone (Cornstones): Herefordshire, Monmouthshire, and Worcestershire.

P. 5032. A fine large shield, broken posteriorly, and wanting the greater portion of the external tuberculated layer; Skirrid-vawr, Abergavenny. A photograph of this specimen forms the frontispiece of the Trans. Woolhope Nat. Field Club, 1868, and a figure is also given in the Geol. Mag. vol. viii. pl. vi. The outline-restoration published by Lankester (*op. cit.* p. 53, woodc. fig. 26) is based upon the same fossil, with the cornua next mentioned. The inferior rim of the shield has been uncovered since the acquisition of the specimen by the Museum.

Presented by John Edward Lee, Esq., 1885.

P. 5033. Two imperfect cornua, found in the same quarry as No. P. 5032, and employed in the restoration just mentioned; from the cabinet of Dr. D. M. McCullough.

Presented by John Edward Lee, Esq., 1885.

41186. Imperfect smaller shield, showing portions of the cornua and the external tuberculated layer, noticed by Lankester, *op. cit.* p. 54; Cradley. *Purchased*, 1868.

42131–32, 42139. Typical shield, somewhat broken, in counterpart, and two much crushed and broken specimens, showing cornua; Cradley. *Baugh Coll.*

42138. Middle portion of shield, showing remains of the external tuberculated layer; locality unknown. *Baugh Coll.*

P. 188–191. Three typical specimens, two being partly in counterpart; Heightington. *Weaver-Jones Coll.*

P. 192. Small crushed and broken shield, perhaps referable to young of this species; Heightington. *Weaver-Jones Coll.*

33319. Fragment of shield, showing external ornamentation, probably referable to young of this species; Ludlow.

Purchased, 1858.

Cephalaspis powriei, Lankester.

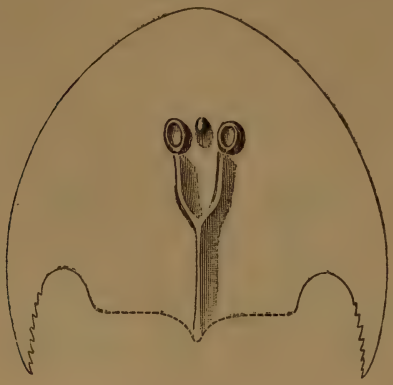
1835. *Cephalaspis lyellii*, L. Agassiz (*pars*), Poiss. Foss. vol. ii. pt. i. p. 142, pl. i. *a*. fig. 1, pl. i. *b*. fig. 1.

1870. *Eucephalaspis powriei*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 47, pl. ix. fig. 5, pl. x. fig. 1, woodc. figs. 19, 20.

Type. Well-preserved fish; collection of J. Powrie, Esq., Reswallie.

Shield sharply rounded in front, broad, and characterized by the peculiar curvature of the outline (fig. 22); orbits placed nearly midway between the anterior and posterior margins; cornua short,

Fig. 22.



Cephalaspis powriei, Lank.—Outline of shield, after Lankester.

broad, acute, and slightly curved inwards. Superficial tuberculations relatively small, closely and irregularly arranged. Scaly trunk about two and a half times as long as the shield.

Form. & Loc. Lower Old Red Sandstone: Forfarshire and Ayrshire.

P. 492. Small well-preserved fish, lateral aspect, figured by Agassiz, *tom. cit.* pl. i. *a.* fig. 1, as *C. lyelli*, and noticed by Lankester, *op. cit.* p. 48; Forfarshire. *Egerton Coll.*

50003. Typical shield, in counterpart; Kinblythemont, Forfarshire. *Trevelyan Bequest.*

Cephalaspis pagei, Lankester.

1870. *Eucephalaspis pagei*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 49, pl. x. figs. 3, 4, pl. xi. fig. 4, woodc. figs. 21, 22.
1870. *Eucephalaspis asper*, E. R. Lankester, *ibid.* p. 50, pl. x. fig. 5 woodc. fig. 23. [Collection of J. Powrie, Esq., Reswallie.]

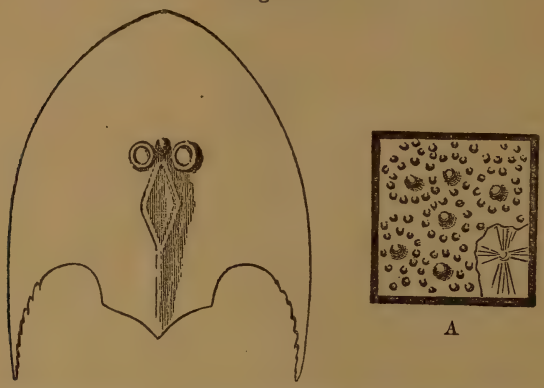
Type. Imperfect fishes; collection of J. Powrie, Esq., Reswallie.

Shield sharply rounded in front; orbits placed nearly midway between the anterior and posterior margins; cornua short, acute, and slightly curved inwards. Superficial ornamentation consisting

of relatively large tubercles surrounded by groups of small tubercles; margin of the shield with a close series of well-developed spinelets.

The outline-restoration of the shield of this species, published by Lankester (fig. 23), appears to be too acute anteriorly, while the cornua seem to be too straight, long, and narrow. The marginal

Fig. 23.



A

Cephalaspis pagei, Lank.—Outline of shield, and a portion of its superficial ornament much magnified (A). After Lankester.

asperities are shown in all the specimens mentioned below, thus confirming Lankester's suspicion that *Eucephalaspis asper* might be only the adult of the present form.

Form. & Loc. Lower Old Red Sandstone: Forfarshire.

P. 122–124. Three typical specimens, showing portions of the head and trunk, the first two being in counterpart; Turin Hill, Forfar. *Purchased*, 1880.

50115. Half of anterior shield, and imperfect lateral aspect of trunk; in micaceous sandstone from Forfarshire. *Purchased*, 1879.

P. 670. Head and trunk about 0·16 in length; Turin Hill. The anterior portion of the shield exhibits traces of the characteristic ornament, and the dentate margin is distinct. The fine rhomboidal squamation of the heterocercal tail is well preserved; and the dorsal and caudal fins occur as granulated membranous expansions. *Egerton Coll.*

P. 125. Imperfect head and trunk of a large individual, in counterpart; Turin Hill. This specimen precisely resembles the typical *C. asper*. *Purchased*, 1880.

Cephalaspis murchisoni, Egerton.

[Plate IX. fig. 6; Plate X. figs. 1–4.]

1857. *Cephalaspis murchisonii*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xiii. p. 284, pl. ix. fig. 1.

1857. *Cephalaspis ornatus*, Sir P. Egerton, *ibid.* p. 285, pl. ix. figs. 2, 3. [Imperfect shield; British Museum.]

1870. *Hemicyclaspis murchisoni*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 51, pl. viii. fig. 6, pl. ix. fig. 1, pl. xii. figs. 3, 4.

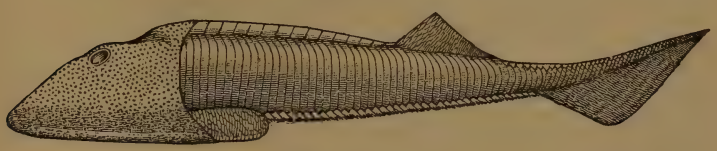
Type. Shield; unknown.

The type species of the subgenus *Hemicyclaspis*, of moderate size. Shield sharply rounded in front; orbits placed nearly midway between the anterior and posterior margins; cornua rudimentary. Superficial ornamentation consisting of widely spaced, regularly arranged, large tubercles, with intervening small tubercles. Scaly trunk about three times as long as the shield.

Form. & Loc. Ludlow Tilestones and Lower Old Red Sandstone Passage Beds: Herefordshire.

The specimens presented by George H. Piper, Esq., recorded below and shown in the accompanying Plates, make known the exoskeleton of this species almost completely, and add important items to our knowledge of the morphology of the Cephalaspidians in general. A restoration is attempted in the woodcut (fig. 24), and the following are detailed notes on the collection.

Fig. 24.



Cephalaspis murchisoni, Egert.—Side view, restored from specimens discovere by George H. Piper, Esq. [Nos. P. 6023, &c.]

The precise form and proportions of the anterior shield have already been determined by Lankester (fig. 25), and the fossils under discussion are quite similar to those previously studied. The absence of posteriorly prolonged cornua is distinctly shown; there is the well-defined high "posterior ridge" behind the "postorbital valley," and the usual three layers entering into the constitution of the shiel are readily distinguishable. There is also no trace of sensory canals.

The superficial ornamentation is not very satisfactorily exhibited, but one specimen (P. 6109) shows an impression of the external surface, represented of four times the natural size in Pl. X. fig. 3; and this evidently conforms to the type described and figured by Lankester in the fossils from the Ludlow Tilestones, named *C. ornatus* by Egerton (fig. 25, A). Lankester's determination of the identity of the latter form with *C. murchisoni* is thus confirmed.

A novel point of much general interest is elucidated by the middle

Fig. 25.

A

Cephalaspis murchisoni, Eg.—Outline of shield, and portion of ornament much magnified (A). After Lankester.

layer of the shield, which is well preserved in several specimens. As already demonstrated by Huxley and Lankester, this layer is divided into a number of distinct polygonal areas, by a system of reticulate, branching vascular canals; and the present specimens prove distinctly that it extends backwards as a pair of postero-lateral "flaps" beyond the rest of the shield. Such an extension is shown in Pl. X. fig. 1, *x*, in the individuals numbered I. and II. in the large group (P. 6023) mentioned below. The outer layer is broken away, so that direct continuity can be observed between the appendage and the middle layer, and the precise shape of most of the areas or plates is distinguishable. As far as the posterior extremity of the shield the outer lateral margin is apparently undivided by vascular channels, and the areas within are approximately as long as broad; but in the appendage the outer border is divided into

oblong portions, the areas immediately within this are at least as long as broad, while those forming the greater part of the "flap" are considerably broader than long, and are suggestive of a certain amount of flexibility in the original structure. The precise outline of the extension is not determinable, but it evidently tapers posteriorly, and its extreme length is nearly equal to half the length of the shield.

Appendages of the character just described have already been noticed by Powrie and Lankester, and, in the absence of satisfactory evidence as to their connections, they have naturally been regarded as pectoral fins. It now appears, however, that the structures are merely a portion of the shield itself, divested of the outer and inner layers to ensure flexibility. The arrangement and peculiarities of the compound plates have, indeed, suggested to Prof. Lankester that these appendages "may have had other functions than that of mere locomotion;" and he adds, as not improbable, "that they may have been efficient in causing currents of water to pass to the branchial organs covered in by the great head-shield (whose outlets are indicated by the lateral perforation in the shield of *Pteraspis*), and have thus aided respiration as well as locomotion, as is observed in the fry of Teleostean fishes at the present day with regard to the pectoral fin." Some connection with the gills has thus already been suspected, and it now seems most probable that the appendages in question actually correspond to a pair of opercula, and may henceforth be designated as such.

The inferior surface of the head is only shown in part by one fossil, and the structures are not sufficiently complete to give any clue as to the characters of the mouth. At least posteriorly, the skin is supported by thin and delicate polygonal plates, closely fitted together (see Pl. X. fig. 2).

As in the more typical members of the genus *Cephalaspis*, the portion of trunk behind the shield is trihedral in form, gradually tapering towards the caudal extremity, and having a segmented appearance, owing to the shape and arrangement of the scutes. As shown distinctly by one specimen (Pl. X. fig. 4) and less distinctly by others, the inferior surface is formed by a single paired series of elongated scutes (*v.*), each broadest at its outer extremity and gradually narrowing while directed forwards mesially. A series of small scutes corresponding in number, and forming a kind of fringe, is arranged along the inferior lateral angle (*l.*) of both sides. Each of these is only connected with the one in front and behind at its base, and the outer free extremity is directed backwards, while the anterior margin is gently rounded and serrated. Again of equal number, and having bevelled ends articulating with the inferior marginals just

described, is the series of vertically elongated lateral scutes (Pl. X. fig. 1, No. 1, and fig. 4, *d.l.*). All these are more or less upright in position, except towards their superior extremities, where they not only become sharply bent forwards, but are also considerably narrowed. There is no modification immediately behind the shield suggesting the presence of a splint system in connection with a pectoral arch, and all the plates, to the number of 46, are of about equal width as far as the position of the dorsal fin; more posteriorly, the lateral scutes are relatively broader and bent forwards at both extremities. Above (as shown especially in Pl. X. fig. 1, No. 1), the crest of the trunk is formed by a single median series of large scutes, Λ-shaped in transverse section, connected and on a level with the "posterior ridge" of the shield. For almost the whole of the distance between the shield and the dorsal fin, this ridge is very high and acute, the angle between the two lateral halves of the scutes being extremely small; more posteriorly, the ridge seems to sink, not being angulated, but gently arched from side to side. While the lateral and ventral scutes are distinctly imbricating, many of these ridge-scutes seem to afford very little provision for flexibility, three or four, indeed, being sometimes fused together in front of the dorsal fin; they are broader than the lateral scutes, each corresponding to one and a half or two of these, but more posteriorly their width is exceeded by that of the laterals. The extremity of the tail is unfortunately too imperfect to show the precise characters of its dermal armour.

No tuberculations are to observed upon the scutes, the external surface, when preserved, apparently only exhibiting the extremely fine, short striæ, which are also seen upon the anterior shield between its tubercular ornament. Most of these striæ are in the direction of the long axis of the trunk, and, when highly magnified, they have a beaded appearance. The free posterior border of all the scutes is destitute of serrations.

On comparing the arrangement of the dermal armour thus described with that already made known by Lankester in the "subgenus *Eucephalaspis*," it will be found to agree in most essential particulars. Many of the points of difference are very possibly to be accounted for by imperfections in the original fossils, the only marked contrast being found in the ventral scutes, which are directed forwards instead of backwards, as determined in the type species (Lankester, pl. xi. fig. 2). It is also considered probable that in the latter the ventral pair of scutes is divided by sutures into four symmetrical pairs; that the upper median scutes are paired, not azygous; and that immediately behind the dorsal fin arrangements change,

the encircling scutes being relatively smaller and more numerous. In some Forfarshire specimens, moreover, the superficial ornamentation is in the form of distinct tubercles.

The new specimens obviously confirm Lankester's suspicion, that there is no "nuchal" plate behind the anterior shield, as was considered possible by Egerton.

Numerous sections of the trunk in various directions show no traces of a hard internal skeleton, and thus are also confirmatory of previous conclusions on the subject, based upon the study of examples of the typical species.

The only fin preserved in Mr. Piper's fossils is the dorsal, which seems to be incompletely shown in No. P. 6023. There are no well-defined fin-rays, the supporting structures being small, oblong, calcified plates, closely fitted together, and placed end to end in vertical parallel series. The arrangement is very suggestive of that of the fragmentary fossils described by Lankester from the Bush Pitch Beds under the name of *Kallostrakon podura* (see p. 175).

45944. Type specimen of *Cephalaspis ornata*, Egerton; Tilestones, Ludlow. *Lightbody Bequest.*

P. 673, P. 676. Two portions of shields; *Auchenaspis*-Grits (Passage Beds), Ledbury, Herefordshire. *Egerton Coll.*

P. 3238–39. Four similar specimens, one being in counterpart; *Auchenaspis*-Grits, Ledbury. *Enniskillen Coll.*

P. 6023. Block of sandstone with more or less fragmentary remains of about twelve individuals, shown, of the natural size, in Pl. X. fig. 1; red sandstone in Passage Beds, Ledbury.
Presented by George H. Piper, Esq., 1889.

P. 5317. Crushed portions of the shield and scaly trunk of two associated individuals, one displaying the operculum; red sandstone, Ledbury.
Presented by George H. Piper, Esq., 1887.

P. 6260. Imperfect shield and anterior portion of the caudal region, the latter fractured and showing the ventral scales (Pl. X. fig. 4, *v.*); red sandstone, Ledbury.
Presented by George H. Piper, Esq., 1890.

P. 6261. Imperfect shield and anterior portion of the caudal region, showing well-preserved dorsal ridge-scales; red sandstone, Ledbury. *Presented by George H. Piper, Esq.*, 1890.

P. 6108. Portion of the anterior shield broken in such a manner as to expose the irregular polygonal dermal calcifications

of the ventral aspect of the body between the inferior rim, shown, of the natural size, in Pl. X. fig. 2; red sandstone, Ledbury. *Presented by George H. Piper, Esq.*, 1889.

P. 5319–20. Impressions of two shields showing absence of cornua, the first displaying the inner aspect, the second the outer; red sandstone, Ledbury.
Presented by George H. Piper, Esq., 1887.

P. 6109. Well-preserved impression of a portion of shield, outer aspect, showing the external ornament (Pl. X. fig. 3); red sandstone, Ledbury.
Presented by George H. Piper, Esq., 1889.

P 5318. Flank-scales of greater portion of trunk, in natural order; red sandstone, Ledbury.
Presented by George H. Piper, Esq., 1889.

P. 6111. Portion of inferior rim of shield, of the form doubtfully, though with much probability, assigned to this species by Lankester (*op. cit.* pl. ix. fig. 4): red sandstone, Ledbury. The fossil is shown, of the natural size, in Pl. IX. fig. 6.
Presented by George H. Piper, Esq., 1889.

Cephalaspis lightbodii, Lankester.

1870. *Cephalaspis lightbodii,* E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 55, pl. xiii. fig. 19.

Type. Inferior rim of shield; British Museum.

A provisionally determined large species, known only by the type specimen and unsatisfactory fragments. Rim of shield ornamented with closely arranged, conical or pyramidal tubercles, having their apices sometimes recurved.

Form. & Loc. Ludlow Tilestones; Ludlow.

45940. Type specimen. *Lightbody Bequest.*

Cephalaspis campbelltonensis, Whiteaves.

[Plate IX. fig. 5.]

1881. *Cephalaspis campbelltonensis,* J. F. Whiteaves, Canadian Naturalist, n. s. vol. x. p. 98.

1889. *Cephalaspis campbelltonensis,* J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 92, pl. x. fig. 2.

1890. *Cephalaspis campbelltownensis*, R. H. Traquair, Geol. Mag. [3] vol. vii. p. 21.

1890. *Cephalaspis whiteavesi*, R. H. Traquair, *ibid.* p. 21. [Shield; Edinburgh Museum.]

Type. Shield; Geological Survey Museum, Ottawa.

A species of large size, the shield with cornua attaining a length of not less than 0·18. Shield produced anteriorly into a short, narrow, sharply rounded rostrum; orbits placed nearly midway between the anterior and posterior margins; cornua long, broad at the base, acutely pointed, slightly inflected, and finely denticulated on the inner margin. Cornua ornamented with fine reticulating rugæ; [ornament of shield unknown].

The peculiar rostrum of this species is solid, much resembling that of *Pteraspis*. It is well shown in the type specimen, though accidentally omitted in the original description and restored outline. As remarked by Whiteaves, the relative proportions of the orbits and interorbital space vary considerably—the result, probably, of accidental crushing.

Form. & Loc. Lower Devonian; Campbellton, New Brunswick.

P. 5477. Slab of shaly rock with remains of four shields, associated with fragments of *Phlyctænaspis* and plants. *Purchased*, 1888.

P. 5970. Remains of a very large shield, with orbits and one cornu. *Purchased*, 1889.

P. 5478. Crushed shield with cornua. *Purchased*, 1888.

P. 5479. Anterior two-thirds of shield, with rostrum, shown, of two-thirds the natural size, in Pl. IX. fig. 5. *Purchased*, 1888.

P. 4576. Similar specimen, with rostrum relatively shorter and more acutely pointed. *Purchased*, 1888.

P. 5971. Fragment with rostrum. *Purchased*, 1889.

P. 5480. Imperfect impression of inner aspect of shield, with the inferior rim. *Purchased*, 1888.

P. 5971 a. Fragment showing part of the hinder border of the shield. *Purchased*, 1889.

P. 5974. Fragmentary squamation, probably of this species. The scales are ornamented with very fine tubercles often fused in series. *Purchased*, 1889.

Cephalaspis dawsoni, Lankester.

1870. *Cephalaspis dawsoni*, E. R. Lankester, Geol. Mag. vol. vii. p. 397, woodcut.

Type. Head and trunk; Redpath Museum, Montreal.

A small species, known only by the type specimen. Shield much broader than long, with prominent cornua; surface very finely tuberculated. Scaly trunk remarkably small and slender in proportion to the shield; infero-lateral scales with serrated free border.

Form. & Loc. Lower Devonian: Gaspé, Canada.

Not represented in the Collection.

Fig. 26.

Cephalaspis dawsoni, Lank.—Dorsal aspect (1), nat. size, and a portion of the tubercular ornament (2), much magnified, after Lankester. Lower Devonian, Canada. [Redpath Museum, Montreal.]

Cephalaspis laticeps, Traquair.

1890. *Cephalaspis laticeps*, R. H. Traquair, Geol. Mag. [3] vol. vii. p. 16.

Type. Shield with remains of squamation; Edinburgh Museum.

Shield proportionately rather broad; cornua short, orbits rather close together, oval, large; tesselated divisions of middle layer very small; external surface ornamented by small, smooth, polished and rounded tubercles, moderately close in position. (*Traquair.*)

The shield in the type specimen measures 0·034 in length and 0·069 in breadth.

Form. & Loc. Upper Devonian: Scaumenac Bay, P. Q., Canada.

Not represented in the Collection.

A fragment apparently of the shield of *Cephalaspis*, from the Lower Devonian of Dickson Bay, Spitzbergen, is recorded by E. R. Lankester, Kongl. Svenska Vetensk.-Akad. Handl. vol. xx. no. 9 (1884), p. 5, pl. i. figs. 4, 5. [Royal State Museum, Stockholm.]

A fragment from the Devonian of Cornwall named *Steganodictyum carteri* by F. M'Coy (Ann. Mag. Nat. Hist. [2] vol. viii. 1851, p. 482, and Brit. Palæoz. Foss. 1855, pl. ii. A. fig. 4) is also recorded as *Cephalaspis* (?) *carteri* by E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc. 1870), p. 42.

Genus **EUKERASPIS,** Lankester.

[Fishes Old Red Sandst. pt. i. (Pal. Soc. 1870), p. 56.]

Syn. *Sclerodus*, L. Agassiz, in Murchison's Silur. Syst. 1839, p. 606 (inappropriate).
Plectrodus, L. Agassiz, *ibid.* p. 606 (inappropriate).

Postero-lateral angles of shield produced into enormous cornua, exceeding the shield in length, and provided on the outer margin with a series of prominent denticulations; a marginal row of about six large quadrate cavities on each side between the two laminæ of the shield.

Eukeraspis is regarded by Lankester as a subgenus of *Auchenaspis*, on the assumption that a second dorsal shield was originally present behind the one already known. The detached cornua were described by Agassiz as jaws of fishes under the names of *Sclerodus* and *Plectrodus*, and seem to have been first correctly interpreted by Harley[1].

Eukeraspis pustulifera (Agassiz).

1839. *Sclerodus pustuliferus*, L. Agassiz, in Murchison's Silur. Syst. pp. 606, 704, pl. iv. figs. 27–32, 60–62.
1839. *Plectrodus mirabilis* and *P. pleiopristis*, L. Agassiz, *ibid.* pp. 606, 704, pl. iv. figs. 14–26.

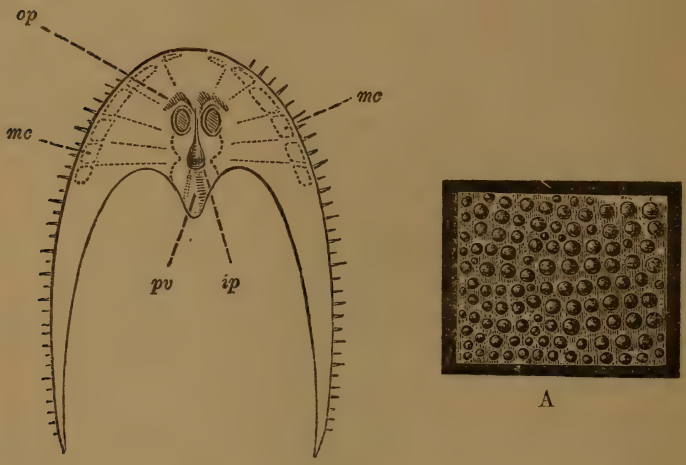
[1] J. Harley, in Murchison's Siluria, ed. 4 (1867), expl. to pl. xxxv.

1854. *Plectrodus* (*Sclerodus*) *pustuliferus*, R. I. Murchison, Siluria, pl. xxxv. figs. 9–12.
1854. *Plectrodus mirabilis*, R. I. Murchison, *ibid.* pl. xxxv. figs. 3–8.
1870. *Eukeraspis pustuliferus*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 58, pl. xiii. figs. 9–14.

Type. Portions of cornua.

The type species, of small size, the maximum total length of the shield with its cornua being about 0·05. Cornua flattened from

Fig. 27.



Eukeraspis pustulifera (Ag.).—Outline of shield, after Lankester. *op.*, antorbital prominence; *mc.*, marginal cells; *ip.*, interorbital prominence; *pv.*, postorbital valley. A. Portion of ornament, much magnified.

above downwards, twice as long as the body of the shield; the external denticulations stout, smooth, and irregularly spaced, with or without feeble intermediate points; superficial tuberculations numerous, small, rounded, and closely arranged.

Form. & Loc. Upper Ludlow and Downton Sandstone: Herefordshire.

45949, a, b. Impression of cornu, and two imperfect shields, figured by Lankester, *op. cit.* pl. xiii. figs. 11, 13, 14; Downton Sandstone, Ludford Lane, Ludlow. *Lightbody Bequest.*

45970, 45973. Cornu and two fragments; Ludford Lane. *Lightbody Bequest.*

45970 a. Two cornua from "Trochus bed," Downton Bridge.
Lightbody Bequest.

P. 3247. Cornu from Bone-bed in Upper Ludlow, near Ludlow
Enniskillen Coll.

P. 5844. Cornu; Downton Sandstone, Kington.
Presented by John Edward Lee, Esq., 1885.

The following specimen is doubtfully assigned to an unknown species of *Eukeraspis*:—

45969. A long, narrow fragment of smooth fibrous bone, denticulated on the thin long margin, and noticed under the name of *Plectrodus* by Egerton, Quart. Journ. Geol. Soc. vol. xiii. (1857), p. 288, pl. x. fig. 2; Downton Sandstone, opposite the Paper-Mill, near Ludlow. The denticles are slender, pointed, and longitudinally grooved, and are arranged in two series, the inner being largest and widely spaced. The bone has more completely the aspect of a jaw than the cornua of the typical *Eukeraspis*.
Lightbody Bequest.

A fragment of denticulated bone from a Lower Palæozoic Boulder, found near Danzig, is also described as *Plectrodus mirabilis* (?) by F. Roemer, Palæont. Abhandl. vol. ii. (1885), p. 359, pl. xxxi. fig. 26. [University of Breslau.]

Genus **AUCHENASPIS,** Egerton.

[Quart. Journ. Geol. Soc. vol. xiii. 1857, p. 286.]

Syn. *Thyestes,* E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, 1854, pt. i. p. 108 (inaccurate definition).

Postero-lateral angles of shield more or less produced into acute cornua, not exceeding the shield in length. Body depressed, ovoid in transverse section; three or four series of dorso-lateral scales fused into a continuous plate immediately behind the shield. Tuberculations in part very large.

Having had the privilege of examining some of the original examples of *Thyestes* described by Eichwald, Pander, and Schmidt, in St. Petersburg, the present writer finds the orbits as distinctly marked in the Oesel fossils as in the typical shields of *Auchenaspis* from Herefordshire. Moreover, some of the specimens of *Auchenaspis egertoni* discovered by Mr. Piper in the Ledbury Passage Beds exhibit traces of the very large tuberculations and the transverse

banding of the posterior shield described as characteristic of *Thyestes*. That the two generic names pertain to a single type thus appears certain, and we prefer that of *Auchenaspis* as being most accurately and recognizably defined.

Auchenaspis salteri, Egerton.

1857. *Auchenaspis salteri*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xiii. p. 286, pl. ix. figs. 4, 5.
1870. *Auchenaspis salteri*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 56, pl. xiii. figs. 7, 8.

Type. Imperfect shield; British Museum.

The type species, of very small size, the two shields having a maximum antero-posterior measurement of about 0·011. Orbits

Fig. 28. Fig. 29.

Fig. 28. *Auchenaspis salteri*, Egert.—Outline of shield, after Lankester.
Fig. 29. *Auchenaspis egertoni*, Lank.—Outline of shield, after Lankester.

placed in advance of the middle point of the anterior shield; cornua not much produced and scarcely divergent; [ornament unknown].

Form. & Loc. Upper Ludlow Tilestones: Ludlow.

45952. Type specimen. *Lightbody Bequest.*

P. 674. Internal impression of shield. *Egerton Coll.*

Auchenaspis egertoni, Lankester.

[Plate X. figs. 5, 6.]

1870. *Auchenaspis egertoni*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 57, pl. xiii. figs. 3–5.

Type. Shields; Oxford Museum.

A species somewhat larger than the type, the two shields having a maximum antero-posterior measurement of about 0·02. Orbits situated in the middle of the anterior shield; cornua divergent, produced to extend at least as far as the hinder margin of the pos-

terior shield; relatively large superficial tuberculations arranged in two or three symmetrical pairs of antero-posteriorly directed lines. Scaly trunk somewhat longer than the two shields.

Form. & Loc. Lower Old Red Sandstone Passage Beds: Ledbury, Herefordshire.

[**P. 6023.**] Small individual, dorsal aspect, mingled with a large group of *Cephalaspis murchisoni* (Pl. X. fig. 1), and shown, of the natural size, in Pl. X. fig. 5. The scaly trunk is somewhat longer than the shield with its posterior plate, and the scutes are apparently arranged as in *Cephalaspis*, the only modifications relating to the more depressed form of the body. In transverse section the trunk is almost a depressed oval; the dorsal ridge is thus less sharp, owing to the wider angle between the two halves of the ridge-scutes, while the lateral scutes are strongly arched in the direction of their long axis.

Presented by George H. Piper, Esq., 1889.

P. 5316. Similar specimen more imperfectly preserved, partly shown in counterpart; from red sandstone in Passage Beds. Immediately behind the posterior dorsal shield, the median series of flattened Λ-shaped dorsal ridge scales occurs, and there are remains also of some of the vertically-elongated flank scales. A small portion of the ventral aspect of the fish is exposed, displaying beneath part of the shield a number of irregular polygonal calcified tesseræ, and also suggestive indications of a broad continuous ventral plate, opposed to the hinder portion of the dorsal shield. *Presented by George H. Piper, Esq.*, 1887.

P. 5315. Imperfect shield in similar matrix.

Presented by George H. Piper, Esq., 1887.

P. 6112. Imperfect shield in similar matrix, displaying portions of the antero-posterior series of large tuberculations, and shown, of the natural size, in Pl. X. fig. 6.

Presented by George H. Piper, Esq., 1889.

36187–90. Four typical shields, from the "*Auchenaspis*-Grit."

Purchased, 1861.

46954. Two associated shields in similar matrix. *Purchased*, 1876.

P. 675. Six shields in similar matrix. *Egerton Coll.*

P. 3237. Four similar specimens, two being associated.

Enniskillen Coll.

P. 5083. Three similar specimens.
Presented by John Edward Lee, Esq., 1885.

P. 5371. Four similar specimens, one showing traces of the large superficial tuberculations. *Purchased*, 1887.

P. 6113 a. Similar specimen, showing traces of the large superficial tuberculations. *Presented by George H. Piper, Esq.*, 1889.

P. 5314, P. 6113. Two imperfect shields in mudstone, the second showing the transverse banding of the posterior plate.
Presented by George H. Piper, Esq., 1887–89.

Auchenaspis verrucosa (Eichwald).

1854. *Thyestes verrucosus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, pt. i. p. 108, pl. ii. fig. 1.
1856. *Cephalaspis verrucosus*, C. H. Pander, Foss. Fische Silur. Syst. p. 47, pl. iv. figs. 1, 3–7.
1858. *Cephalaspis verrucosus*, T. H. Huxley, Quart. Journ. Geol. Soc. vol. xiv. p. 269.
1860. *Thyestes verrucosus*, E. von Eichwald, Leth. Rossica, vol. i. pt. ii. p. 1532.
1866. *Thyestes verrucosus*, F. Schmidt, Verhandl. russ.-kais. mineral. Ges. St. Petersburg, [2] vol. i. p. 225, pl. iv. figs. 1–12.

Type. Shield; University of St. Petersburg.

The type species of *Thyestes*. Shield resembling that of *A. egertoni* in form and proportions; external margin of anterior plate with a regular close series of blunt tuberculations; transverse sulci between the components of the posterior plate prominent. Superficial ornament consisting of three symmetrically arranged, paired, longitudinal series of large tubercles, extending the whole length of the shield, with irregularly scattered small tubercles between; the longitudinal median ridge of the posterior plate apparently consisting of imperfectly-fused large tubercles.

As remarked by Huxley and Schmidt, the supposed jaws described by Pander are fragments of the tuberculated rim of the anterior shield. The orbits have not been indicated in published figures and descriptions, but they are as distinctly shown in some of the original specimens as in the typical *Auchenaspis* from Herefordshire. The markings determined as orbits by Schmidt are too far forwards and too small, and the supposed median longitudinally-elongated vacuity is the now well-known large superficial fossa.

Form. & Loc. Upper Silurian: Isle of Oesel, Baltic Sea.

Not represented in the Collection.

Genus **DIDYMASPIS,** Lankester.

[Geol. Mag. vol. iv. 1867, p. 152.]

An imperfectly known genus, with two anterior dorsal shields, differing only from those of *Auchenaspis* in the absence of prominent cornua, and in the relatively greater size of the hinder shield. A large ventral shield is opposed to the latter.

Didymaspis grindrodi, Lankester.

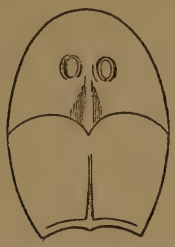
[Plate IX. figs. 7, 8.]

1867. *Didymaspis grindrodi*, E. R. Lankester, Geol. Mag. vol. iv. p. 153, pl. viii. figs. 4–7.
1870. *Didymaspis grindrodi*, E. R. Lankester, Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 59, pl. xiii. figs. 1, 2.

Type. Shield; Oxford Museum.

The type species, of small size, the maximum antero-posterior measurement of the two shields being about 0·025, and their maximum breadth 0·018. The two dorsal shields firmly united, the anterior somewhat smaller than the posterior, and the latter tapering, though abruptly truncated behind; the line of junction between the two shields describing a double curve, the produced lateral

Fig. 30.



Didymaspis grindrodi, Lank.—Outline of shield, after Lankester.

angles of the anterior portion embracing the posterior portion, but not diverging from it, while in the median line the anterior shield is produced into the posterior to a small extent. Superficial ornamentation consisting of irregularly arranged fine tubercles; a faint median keel in the hinder half of the posterior shield.

Form. & Loc. Lower Old Red Sandstone: Ledbury, Herefordshire.

P. 5043. A typical specimen showing an impression of the inner aspect of the dorsal shield, with a loose portion of matrix lying between the hinder plate of this shield and an equally large, opposed ventral plate, of which the substance is preserved; Bush Pitch, near Ledbury. The portion of matrix representing the space occupied by the soft parts of the animal is very thin, as shown in the transverse section, Pl. IX. fig. 7 *a*. The ventral plate (Pl. IX. fig. 7), as seen from the visceral aspect, is flattened, marked with the numerous openings of apparently vascular canals, and is not seen to extend beneath the anterior shield.

Presented by John Edward Lee, Esq., 1885.

P. 5313. Dorsal aspect of shield, showing portions of the external tuberculated layer; Bush Pitch. The specimen is shown, of the natural size, in Pl. IX. fig. 8, and a portion of the ornament enlarged four times in fig. 8 *a*. The posterior plate is gently rounded from side to side, with only faint indications of a longitudinal median keel in the hinder half; and the superficial ornamentation consists of numerous rounded tubercles, closely, but irregularly arranged.

Presented by George H. Piper, Esq., 1887.

A fossil of very doubtful relationships, sometimes assigned to the family of Cephalaspidæ, is described as follows:—

Menaspis armata, T. Ewald, Bericht k. preuss. Akad. Wiss. 1848, p. 33; H. B. Geinitz, Dyas (1861), p. 21.—Upper Permian (Zechstein); Lonau, Harz Mts. [Collection of Dr. Ewald, Berlin.]

Another supposed ally of the Cephalaspidæ is described thus:—

Cephalopterus pagei, J. Powrie, Trans. Edinb. Geol. Soc. vol. i. (1870), p. 298, pl. xiv. fig. 16.—Lower Old Red Sandstone; Turin Hill, Forfar. [Collection of James Powrie, Esq., Reswallie, and Dundee Museum.]

Family TREMATASPIDÆ.

Shield rounded or tapering in front, abruptly truncated behind; interorbital piece not fixed; external surface covered with punctate ganoine, the punctations often arranged in reticulating lines; superficial tuberculations almost or entirely absent.

Genus **TREMATASPIS,** Schmidt.

[Verhandl. russ.-kais. mineral. Ges. St. Petersburg, [2] vol. i. 1866, p. 233.]

Syn. (?) *Stigmolepis,* C. H. Pander, Foss. Fische Silur. Syst. 1856, p. 53. *Odontotodus,* C. H. Pander, *ibid.* p. 75 (inappropriate).

Shield simple, the postero-lateral angles not produced into cornua; a continuous ventral plate opposed to its posterior two-thirds. A circular depression immediately in advance of the orbital opening, with an antero-posteriorly elongated cleft in the centre; an oval fossa or cleft behind the orbital opening.

In the ordinary state of preservation of the shield it is difficult to distinguish broken eminences and depressions from vacuities; and it is quite possible that the post-orbital and lateral openings

Fig. 31. Fig. 32.

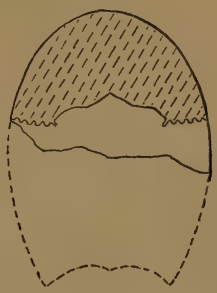


Fig. 31. *Tremataspis schrenki* (Pander).—Outline of shield, dorsal aspect, after F. Schmidt.

Fig. 32. *Tremataspis schrenki* (Pander).—Outline of anterior portion of shield, ventral aspect, after F. Schmidt.

described by Schmidt are due to features of this kind accidentally removed. The appearances are distinct in the original specimens, and, whether they be due to vacuities, eminences, or depressions, they are at present not readily interpreted.

Trematapsis schrenki (Pander).

1856. *Cephalaspis schrenkii*, C. H. Pander, Foss. Fische Silur. Syst. p. 47, pl. iv. fig. 2.
(?) 1856. *Stigmolepis owenii*, C. H. Pander, *ibid.* p. 53, pl. v. fig. 7.
1856. *Odontotodus rootsikuellensis*, C. H. Pander, *ibid.* p. 75, pl. vi. fig. 21.
1866. *Trematapsis schrenkii*, F. Schmidt, Verhandl. russ.-kais. mineral. Ges. St. Petersburg, [2] vol. i. p. 233, pls. v., vi.

Type. Fragment of shield; School of Mines, St. Petersburg.

Shield depressed, gently rounded, longer than broad; anterior margin obtusely rounded; lateral margin, and the anterior margin of the ventral shield, coarsely crenulated; posterior margin slightly excavated. Orbital opening situated at about one-fifth of the total length of the shield from its anterior extremity; postorbital "vacuity" antero-posteriorly elongated, pear-shaped; a faint median longitudinal ridge towards the hinder end of the shield.

Form. & Loc. Upper Silurian: Rootsiküle, Isle of Oesel.

Not represented in the Collection.

The so-called Chordate genus and species, *Mycterops ordinatus*, E. D. Cope, Amer. Naturalist, 1886, p. 1029, woodcut, from the Coal-measures of Pennsylvania, is founded upon an imperfect shield of an Eurypterid in the collection of Prof. E. D. Cope, Philadelphia (A. S. Woodward, Geol. Mag. [3] vol. vii. 1890, p. 395).

Order III. ANTIARCHA.

Exoskeleton consisting of calcifications with bone-corpuscles, and invested with a more or less continuous superficial layer of ganoine. Dermal sense-organs occupying open grooves upon the exoskeleton. Dorsal and ventral shields consisting of several symmetrically arranged pieces, and the head articulated with the trunk; orbits close together. Paired fins represented by paddle-like appendages covered with dermal plates.

The only family of this order as yet determined with certainty is that of the Asterolepidæ.

Family ASTEROLEPIDÆ.

Exoskeleton robust, ornamented with tuberculations of ganoine; dorsal and ventral shields of trunk firmly united by the lateral plates. Orbits very closely approximated, and the interorbital piece loose. A pair of paddle-like appendages, completely encased in bony plates, articulated by a complex joint with the anterior ventro-lateral plates of the trunk; median fins not continuous.

As pointed out especially by Traquair, the dermal plates in the genera of this family are arranged upon one definite plan, and the most satisfactorily known genus, *Pterichthys*, may be taken as a typical example. This is described in detail under its generic heading (p. 208), and notes on the homologous parts of *Bothriolepis* are added later (p. 224).

Synopsis of Genera.

I. Pectoral appendages shorter than the body-armour.
  Anterior median dorsal plate overlapping the dorso-laterals ..... *Asterolepis* (p. 203).
  Anterior median dorsal plate overlapping the anterior dorso-lateral, overlapped by the posterior dorso-lateral ..... *Pterichthys* (p. 208).
  Anterior median dorsal plate in front overlapping and behind overlapped by the anterior dorso-lateral and the posterior dorso-lateral ..... *Microbrachium* (p. 223).
II. Pectoral appendages longer than the body-armour.
  Anterior median dorsal plate overlapping the anterior dorso-lateral, overlapped by the posterior dorso-lateral ..... *Bothriolepis* (p. 223).

Genus **ASTEROLEPIS,** Eichwald.

[Bull. Sci. St.-Pétersbourg, vol. vii. 1840, p. 79 (*Astrolepis*).]

Syn. *Chelonichthys*, L. Agassiz, Poiss. Foss. vol. i. 1844, p. xxxiii (name only).
Odontacanthus, L. Agassiz, Poiss. Foss. V. G. R. 1845, pp. 111, 114.
(?) *Actinolepis*, L. Agassiz, *ibid.* p. 141.
(?) *Narcodes*, L. Agassiz, *ibid.* pp. 111, 115.

Head and trunk broad, not much elevated, the scutes ornamented

with tubercles; [tail unknown]. Lateral sensory canals upon the upper aspect of the head united by an anterior transverse commissure crossing the premedian plate, and by a posterior one directly crossing the median occipital; anterior median dorsal plate overlapping both the anterior and posterior dorso-laterals. Pectoral appendages shorter than the armoured trunk, segmented into a distal and proximal portion.

This genus is only known from isolated dermal plates so similar in form to those of *Pterichthys* as to have induced C. H. Pander[1] to regard the last-mentioned name as a synonym. The only undoubted distinguishing feature, according to R. H. Traquair[2], is the mode of overlapping of the anterior median dorsal plate. The tail, however, is still unknown.

Asterolepis ornata, Eichwald.

1840. *Astrolepis*, E. Eichwald, Bull. Sci. St.-Pétersbourg, vol. vii. p. 79.
1840. *Asterolepis ornata*, E. Eichwald, Neues Jahrb. p. 425.
1844. *Asterolepis ornatus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. p. 829.
1845. *Asterolepis ornata*, L. Agassiz, Poiss. Foss. V. G. R. p. 93, pl. B. fig. 4; pl. xxx. figs. 2–9 (? in part).
(?) 1845. *Asterolepis apicalis*, L. Agassiz, *op. cit.* p. 148, pl. xxxi. *a.* fig. 31.
1857. *Asterolepis*, C. H. Pander, Placoderm. devon. Syst. p. 44, pl. v. figs. 10, 11, pl. vi. figs. 1–4, pl. vii. figs. 1, 8, pl. viii. fig. 4, pl. B. figs. 6, 7, 10, 13, 14.
1860. *Asterolepis ornata*, E. von Eichwald, Leth. Rossica, vol. i. p. 1508 pl. lvi. fig. 1.

Type. Detached dermal plates; University of St. Petersburg.

The type species. Anterior median dorsal plate not carinated longitudinally, its anterior extremity almost as broad as the posterior. Unworn superficial tubercles with prominently stellate bases, irregularly arranged, and sometimes fused together; outer margin of pectoral appendages acute and coarsely denticulated.

Form. & Loc. Devonian: Baltic Provinces and Government of Novgorod, Russia.

The following specimens are detached plates from the neighbourhood of Dorpat, and, unless otherwise stated, were obtained by purchase, 1868:—

41090 a. Premedian.

[1] Die Placodermen des devonischen Systems (1857), p. 44.

[2] Geol. Mag. [3] vol. v. (1888), p. 508; also Ann. Mag. Nat. Hist. [6] vol. ii. (1888), p. 492.

41090 b. Two examples of postmedian.

41090 c. Two imperfect large and one small example of median occipital.

41090 d. One left and two right lateral occipitals.

41090 e. Portion of right anterior ventro-lateral.

P. 1 a. Portion of left anterior ventro-lateral. *Purchased*, 1879.

41091 a. Two examples of articular.

P. 1 b, c. Large and small similar plates. *Purchased*, 1879.

41091 b. Inner second marginal.

41091 c. Inner proximal marginal.

41091 d. Outer proximal marginal.

41091 e. Distal half of anconeal.

41091 f, g. Two doubtful plates, perhaps distal centrals.

41091 h. Proximal inner marginal of distal segment.

41091 i. Two outer distal marginals.

41091 j. Terminal plate of limb.

Asterolepis concatenata, Eichwald.

1844. *Pterichthys concatenatus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. p. 829.

1845. *Asterolepis concatenata*, E. von Eichwald, Archiv f. Mineral., Geogn., etc., vol. xix. p. 674.

(?) 1845. *Actinolepis tuberculatus*, L. Agassiz, Poiss. Foss. V. G. R. p. 141, pl. xxxi. figs. 15–18.

1845. *Chelyophorus pustulatus*, L. Agassiz, *ibid.* p. 136, pl. xxxi. *a.* figs. 20, 21.

1857. *Asterolepis concatenatus*, C. H. Pander, Placoderm. devon. Syst. p. 102, pl. vii. fig. 7 [? also fragment without name, *ibid.* pl. vii. fig. 25.]

1860. *Asterolepis concatenata*, E. von Eichwald, Leth. Rossica, vol. i. p. 1509.

Type. Median occipital plate; University of St. Petersburg.

An imperfectly determined species, somewhat smaller than *A. ornatus*, and described as differing in the frequent arrangement of the superficial tuberculations in distinct regular series.

Form. & Loc. Devonian: Marjina, near Pawlowsk, Govt. of St. Petersburg, Russia.

Not represented in the Collection.

Asterolepis maxima (Agassiz).

[Plate V. fig. 1.]

1845. *Coccosteus maximus*, L. Agassiz, Poiss. Foss. V. G. R. p. 137, pl. xxx. *a*. figs. 17, 18.

1848. *Pterichthys major*, H. Miller (*non* Agassiz), Quart. Journ. Geol. Soc. vol. iv. p. 311.

1857. *Asterolepis*, C. H. Pander, Placoderm. devon. Syst. p. 17.

1860. *Coccosteus maximus*=*Asterolepis ornata*, E. von Eichwald, Leth. Rossica, vol. i. p. 1508.

1888. *Asterolepis maximus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 508, and Ann. Mag. Nat. Hist. [6] vol. ii. p. 494, pl. xviii. figs. 1, 2.

Type. Imperfect anterior median dorsal plate; Geological Society of London.

A very large species, attaining more than twice the size of *A ornata*. Anterior median dorsal plate with a faint longitudinal carina; anterior extremity tapering, its breadth being not more than half that of the posterior extremity. Superficial tubercles large, rounded, closely arranged, rarely fused together.

The type specimen of this species was regarded by Agassiz as a median ventral plate, but is shown by Miller and Pander to be anterior median dorsal, while the last-named author determines its correct generic position.

Form. & Loc. Upper Old Red Sandstone: Nairn.

38710–15. Six imperfect examples of the anterior median dorsal plate in various states of preservation. The first specimen measures 0·15 in length, is exposed from the inner aspect, and displays portions of the lateral overlapping edges; it is shown, of one third the natural size, in Pl. V. fig. 1.
Purchased, 1864.

36001. Smaller anterior median dorsal plate. *Purchased*, 1861.

P. 5052. Imperfect impression of a similar plate; King's Steps.
Presented by John Edward Lee, Esq., 1885.

28875. Right posterior dorso-lateral. *Purchased*, 1854.

38716. Right posterior dorso-lateral. *Purchased*, 1864.

P. 5052 a. Imperfect similar plate, displaying areas overlapped by the median dorsals.
Presented by John Edward Lee, Esq., 1885.

28875 a. Portion of lateral plate. *Purchased*, 1885.

P. 5052 b. A small imperfect plate, 0·06 in length, probably part of a median dorsal; King's Steps.

Presented by John Edward Lee, Esq., 1885.

Fragments of the pectoral appendages of *Asterolepis*, from the Devonian of Russia, are also described under the following names:—

Odontacanthus crenatus, L. Agassiz, Poiss. Foss. V. G. R. (1845), pp. 111, 115, pl. xxxiii. fig. 7: *Ctenoptychius crenatus*, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 173.—Devonian; Megra.

Odontacanthus heterodon, L. Agassiz, *ibid.* (1845), pp. 111, 115, pl. xxxiii. fig. 8.—Devonian; near Riga.

Narcodes pustulifer, L. Agassiz, *ibid.* (1845), pp. 111, 115, pl. xxxiii. fig. 9.—Devonian; near St. Petersburg.

Dermal plates of Ostracoderms, &c., too imperfect for satisfactory determination, have also been assigned to *Asterolepis* under the following names:—

Asterolepis australis, F. M'Coy, Prodr. Palæont. Victoria (Geol. Surv. Vict.), dec. iv. (1876), p. 19, pl. xxxv. fig. 7 (regarded as variety of *A. ornata*).—Middle Devonian; Buchan River, North Gippsland, Victoria. [Melbourne Museum.]

Asterolepis bohemica, J. Barrande, Syst. Silur. Bohême, vol. i. Suppl. (1872), p. 637, pl. xxix.—Upper Silurian (g 1); Chotecz, Bohemia. [Royal Bohemian Museum, Prague.]

Asterolepis depressa, E. von Eichwald, Archiv f. Mineral., Geogn., &c., vol. xix. (1845), p. 674, and Leth. Rossica, vol. i. (1860), p. 1510: *Pterichthys depressus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. (1844), p. 829.—Devonian; Marjina, near Pawlowsk, and River Aa, Livonia. [University of St. Petersburg.]

Asterolepis granulata, L. Agassiz, Poiss. Foss. V. G. R. (1845), pp. 94, 147, pl. xxx. fig. 12, pl. xxx. *a*. fig. 12.—Devonian; Riga.

Asterolepis malcolmsoni, L. Agassiz, *ibid.* (1845), p. 147, pl. xxx. *a*. fig. 16.—Upper Old Red Sandstone; Scat Craig, Elgin. [? *A. maxima*.]

Asterolepis minor, L. Agassiz, *ibid.* (1845), pp. 94, 147, pl. xxviii. *a*. fig. A (in part), pl. xxx. fig. 11, pl. xxxi. *a*. figs. 29, 30: *Asterolepis miliaris*, L. Agassiz, *ibid.* p. 61: *Chelonichthys*

minor, L. Agassiz, Poiss. Foss. vol. i. (1844), p. xxxiii (name only).—Devonian; Riga and St. Petersburg. Upper Old Red Sandstone; Elgin. [Original of Agassiz, pl. xxx. fig. 11, considered as probably referable to *Asterolepis concatenata* by E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1510.]

Asterolepis speciosa, L. Agassiz, *op. cit.* (1845), pp. 93, 146, pl. xxx. fig. 10, pl. xxx. *a*. fig. 4.—Devonian; Voronèje, Russia.

Asterolepis wenkenbachii, C. Koch, Verhandl. naturh. Verein., Bonn, vol. xxix. (1872), Correspond. p. 85 (name only).—Devonian; Eifel.

Genus **PTERICHTHYS**, Agassiz.

[Poiss. Foss. V. G. R. 1844, p. 6.]

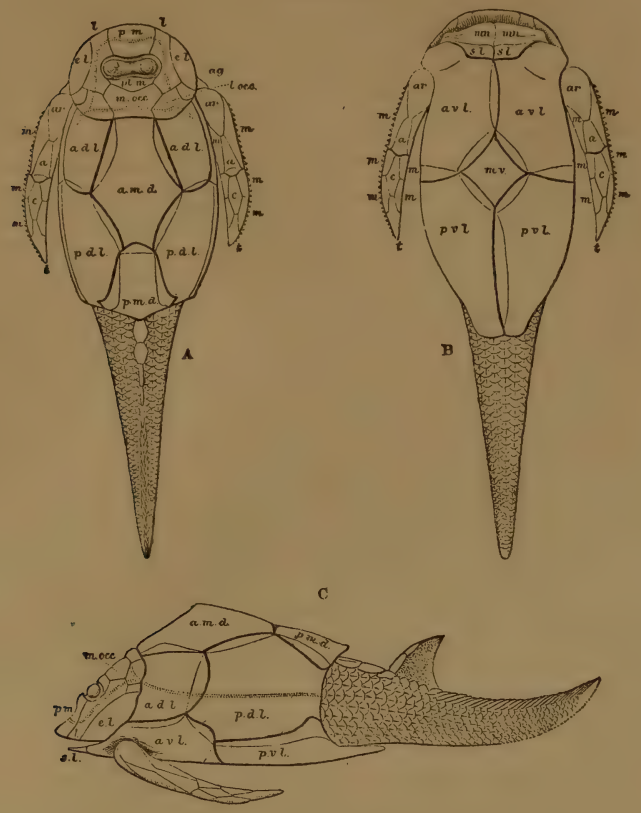
Head and trunk broad, but much elevated, the scutes ornamented with tubercles; tail covered with rounded or hexagonal scales, slightly imbricating. Lateral sensory canals on the upper aspect of the head united by an anterior transverse commissure crossing the premedian plate, and a posterior one directly crossing the median occipital; anterior median dorsal plate overlapping the anterior dorso-lateral, overlapped by the posterior dorso-lateral. Pectoral appendages shorter than the armoured trunk, segmented into a distal and proximal portion; marginal scutes of proximal portion separated above and below by a median "anconeal" element; marginal and central scutes of distal portion few. A single small median dorsal fin, with large anterior fulcral scales, but apparently no fin-rays.

The exoskeleton of this genus is now tolerably well known, owing especially to the researches of Miller, Pander, and Traquair; and the accompanying restorations (fig. 33, A, B, C) are those of the last-named author. Fig. A represents the dorsal aspect, and fig. B the ventral aspect, while fig. C is a side view. The exposed margins of the plates of the trunk are shown by thickened lines, while the amount and direction of their overlap are indicated by the thin lines. Sensory canals, both upon the head and trunk, are marked by double dotted lines. We would only add that the large inferior expansion of the caudal fin is omitted in the third figure (compare Pl. VI. fig. 3, *x*); and for the details of the hard parts in the orbital opening, reference must be made to some of the specimens described below, notably the original of Pl. V. fig. 2.

The cranial shield is small compared with the armour of the

trunk, and, so far as known, is confined to the dorsal and lateral aspects. A large transverse opening, somewhat constricted mesially, occurs in the middle of the roof; and all the constituent plates of

Fig. 33.



Pterichthys testudinarius, Ag.; restored by R. H. Traquair, from the dorsal aspect (A), ventral aspect (B), and lateral aspect (C). In the last figure the caudal fin is omitted. The double dotted lines indicate the grooves of the sensory canal-system; and in the trunk, the thick lines represent the exposed borders of the plate, the thin line showing the extent of the overlap. *a.*, anconeal; *a.d.l.*, anterior dorso-lateral; *a.m.d.*, anterior median dorsal; *a.v.l.*, anterior ventro-lateral; *ag.*, angular; *ar.*, articular; *c.*, central; *e.l.*, extra-lateral (or operculum); *l.occ.*, lateral occipital; *m.*, marginal; *m.occ.*, median occipital; *m.v.*, median ventral; *mn.*, mental; *p.m.*, premedian; *p.d.l.*, posterior dorso-lateral; *p.m.d.*, posterior median dorsal; *p.v.l.*, posterior ventro-lateral; *pt.m.*, post-median; *s.l.*, semilunar.

the shield, except the postero-lateral pair, are firmly fixed together by sutures. There is a crown-shaped median occipital (*m.occ.*), bounded upon either side by a somewhat smaller lateral occipital (*l.occ.*), and separated from the great opening in front by a narrow, transversely elongated, postmedian plate (*pt.m.*). A very small, approximately quadrate angular plate (*ag.*) adjoins the outer margin of the lateral occipital on each side; and a long, narrow, lateral element (*l*) extends on each side of the median opening from the front margin of these plates continuously to the rostral border of the shield. A large single premedian plate (*p.m.*) is interposed between the anterior extremities of these laterals, forming both the front border of the median opening and the extremity of the snout. The narrow space on each side, between the lateral and angular plates and the anterior border of the armour of the trunk, is filled by a loose extra-lateral plate (*e.l.*), which seems to have formed the operculum; its posterior margin was evidently free, but its anterior strongly convex margin is notched in such a manner as to suggest the ordinary articulation of a fish-operculum (see Pl. V. fig. 6). The orbits seem to have occupied the rounded extremities of the great median opening, these being separated by a thick, loose, quadrate plate, with laterally produced hinder angles, well shown from the inner aspect in Pl. V. fig. 2, *p*; this element (the "os dubium" of Pander) is ornamented externally, but exhibits a deep pit in the middle of its inner face, evidently for the reception of the pineal body, and it may thus be known as the pineal plate. Immediately in front of the latter there seems to be a thin, narrow bone (see No. 19804a, p. 222), but this has not yet been clearly observed. In the position of the orbits themselves, a thin, oval, convex or concave, smooth plate is often observed (Pl. V. fig. 2, *o*), and this may probably be interpreted as an ossification in the sclerotic.

The sensory canals upon the cranial shield are nearly parallel with its border, one directly crossing the median occipital plate transversely, another similarly crossing the premedian, and a lateral pair extending along the long axis of the laterals. These and the transverse hinder canal meet in an angulation on the lateral occipitals, whence also a branch runs along the dorso-lateral plates of the trunk, forming the "lateral line."

The head seems to have been movably articulated with the trunk, but not by any ginglymoid processes or surfaces. The dermal armature apparently extends over the whole of the abdominal region, but does not include the anus. Its ventral surface is flattened, while the dorsal shield is much arched; and all the plates are deeply overlapping. There are two median dorsal

elements, the anterior (*a.m.d.*) larger than the posterior (*p.m.d.*); and these are bounded by two dorso-lateral pairs (*a.d.l.* and *p.d.l.*), of which the hinder is much the largest. There are two pairs of ventro-lateral plates (*a.v.l.* and *p.v.l.*), which meet in the mesial line below, and are sharply reflexed upwards at the sides to overlap the inferior edge of the dorso-laterals; while on the ventral surface there occurs a small, median, diamond-shaped space between the inner truncated angles of these plates, filled by a much-overlapped median ventral (*m.v.*). The slightly excavated front border of the anterior ventro-laterals is filled by a pair of small semilunar plates (*s.l.*) tapering outwardly; and again in advance of these is a pair of much larger, transversely elongated elements (*mn.*), concave above, which have been termed mental by Traquair. The latter plates are loosely fixed and often displaced (see Pl. V. fig. 3, *mn.*), but can scarcely be interpreted as a mandible. At a point somewhat in advance of their hinder extremities, the posterior ventro-lateral plates are distinctly constricted, with an inner transverse thickening; and this may mark the termination of the abdominal cavity.

Near their front extremity the anterior ventro-lateral plates are strengthened by a robust transverse ridge on the visceral aspect, and close to this the pectoral appendages are fixed by a most complex, ginglymoid articulation. Each appendage is completely encased in closely-fitting plates; and a large orifice in the supporting articular facette bears witness to the passage into its interior of well-developed vascular canals and nerves. A powerful articular plate (*ar.*), with rounded proximal end, occurs both on the dorsal and on the ventral aspect of the appendage; an inner and an outer marginal (*m.*), with an upper and a lower median anconeal plate (*a.*), are closely united with these, and at the distal extremity of this group of plates the appendage is jointed. The distal segment is shorter and smaller than the proximal, consisting of an upper and lower central piece (*c.*), a pointed terminal plate (*t.*), and two pairs of marginals (*m.*).

The tail is comparatively small, covered with imbricating rounded or hexagonal scales, with a series of large azygous ridge-scales on the dorsal aspect. The body-scales are thin and finely tuberculated (see Nos. P. 3209, P. 4036), while the dorsal ridge-scales are comparatively robust. The latter are interrupted shortly behind the posterior median dorsal plate by a small triangular dorsal fin; this being membranous, and only stiffened on its front margin by one (or perhaps two) of the scales, which might be mistaken for a spine. Behind the fin, the ridge-scales are very deeply imbricating to the extremity of the tail, which is somewhat upturned (Pl. V. fig. 5),

and is bordered below by a large membranous caudal fin (Pl. VI. fig. 3, *x*) of uncertain shape. There are no pelvic fins, the determination of their presence by Egerton [1] being founded upon a mistake [2].

Pterichthys milleri, Agassiz.

[Plate V. figs. 2–7.]

1841. *Pterichthys milleri*, H. Miller (*ex* Agassiz), Old Red Sandstone, p. xxii, pls. i. & ii.

1844. *Pterichthys milleri* and *P. latus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 302 (names only).

1844. *Pterichthys latus*, L. Agassiz, Poiss. Foss. V. G. R. p. 12, pl. iii. figs. 3, 4. [British Museum and Forres Museum.]

1844. *Pterichthys milleri*, L. Agassiz, *ibid.* p. 15, pl. i. figs. 1–3.

1848. *Pterichthys quadratus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iv. p. 313, pl. x. [Geological Society of London.]

1848. *Pterichthys latus*, Sir P. Egerton, *ibid.* p. 312.

1855. *Pterichthys latus*, F. M'Coy, Brit. Palæoz. Foss. p. 600.

1888. *Pterichthys milleri*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 509.

Type. Head, trunk, and base of tail, ventral aspect; Edinburgh Museum.

The type species. Inferior surface of carapace broadly ovate; tail about equal in length to the trunk. Pectoral appendages two-thirds as long as the trunk, not expanded, tapering.

Form. & Loc. Lower Old Red Sandstone: Cromarty, Banffshire, and Nairnshire.

P. 6259. Paper model of carapace, made by Hugh Miller.
Egerton Coll.

(i.) Cromarty (typical *P. milleri*).

19804. Imperfectly preserved small specimen in counterpart.
Purchased, 1845.

P. 654. Imperfect similar specimen, wanting head; bearing autograph of Hugh Miller. *Egerton Coll.*

P. 3213. Small crushed trunk and head, in counterpart.
Enniskillen Coll.

21974. Imperfect head, trunk, and pectoral appendages, ventral aspect, as large as the typical *P. latus*. *Purchased*, 1848.

[1] Quart. Journ. Geol. Soc. vol. xvi. (1860), p. 127.
[2] R. H. Traquair, Geol. Mag. [3] vol. v. (1888), p. 509.

P. 5599. Remains of a large trunk, with the right pectoral appendage, ventral aspect. *Purchased*, 1889.

(ii.) Lethen Bar (typical *P. latus*).

P. 533. One of the type specimens of *P. latus*, figured by Agassiz, *op. cit.* pl. iii. fig. 4. As remarked by Egerton, the fossil exhibits the ventral aspect, and most of the bone-substance is removed. *Egerton Coll.*

28857. Crushed individual, dorsal aspect. The parts of the head are mostly obscured, but the mental plates are distinguishable, and the pineal or "os dubium," with its median pit, is well shown. The anterior median dorsal plate is almost destroyed, but the smaller second dorsal is more complete; and immediately below and behind the latter occur the hinder extremities of the posterior ventro-laterals. Nothing worthy of note is presented by the tail; but in the left pectoral appendage, the transversely striated ginglymus upon which the distal segment moves is distinct. *Purchased*, 1854.

49187. Trunk with head and fragments of the appendages and tail, ventral aspect, preserved in counterpart. The head is completely severed from the trunk, and the roof is shown from beneath, of the natural size, in Pl. V. fig. 2. In addition to some of the elements ordinarily observed, and marked with letters in the figure, the pineal plate (*p.*) is well seen, with its central pit, and also one of the orbital plates (*o.*); moreover, a small process is observed to extend from the middle of the anterior margin of the postmedian plate (*pt. m.*). One of the extra-lateral plates is detached; and the plates of the appendages are scattered and broken. *Purchased*, 1878.

49191. Head, trunk, limbs, and scattered remains of the tail, ventral aspect, preserved in counterpart. The posterior ventro-lateral plates exhibit denticulations on the hinder margin. *Purchased*, 1878.

50109. Nearly complete individual, dorsal aspect, much crushed, and preserved in counterpart. The specimen is shown of the natural size in Pl. V. fig. 3. In the head the most important feature displayed is the pair of mental plates (*mn.*); they are somewhat displaced forwards, and their superior (or visceral) aspect is distinctly concave. The

extra-laterals (*e.l.*) are also shown, almost in their natural position. As far as the hinder margin of the anterior median dorsal plate, the roof of the carapace is preserved, but more posteriorly the posterior ventro-laterals are exposed from the visceral aspect, and the posterior median dorsal plate is seen only in impression in the counterpart. The anterior median dorsal (*a.m.d.*) is slightly narrower in front than behind, and its longitudinal keel rises to a prominent apex in the centre. The anterior dorso-lateral plates (*a.d.l.*) distinctly overlap the posterior dorso-laterals (*p.d.l.*); and the usual constriction near the hinder extremity of the posterior ventro-laterals (*p.v.l.*) is well seen. The cycloidal scales of the tail exhibit no features worthy of special note; and the large fulcral scale at the anterior margin of the dorsal fin (*d.*), though preserved, is apparently much broken. *Purchased*, 1879.

50110. Individual with incomplete head, preserved in counterpart, and shown of the natural size in Pl. V. fig. 4. Many of the plates are distinctly exhibited, notably the right posterior ventro-lateral; and the form and proportions of the pectoral appendages are indicated. Towards the extremity of the tail occur traces of the dorsal fulcral scales (*f.*); and a ferruginous stain may indicate the original presence of a terminal fin, or may be merely an aggregation of mineral matter round the point.
Purchased, 1879.

P. 6262. Portions of the head and pectoral appendages, and the ventral plates seen from the visceral aspect.

P. 658, P. 3204. Two examples of the imperfect trunk, in counterpart, ventral aspect. *Egerton & Enniskillen Colls.*

28858. Portions of head and trunk, with pectoral appendages.
Purchased, 1854.

P. 659. Tail, labelled *P. latus* by Agassiz, showing dorsal fin accidentally divided and appearing as if a pelvic pair; noticed by R. H. Traquair, Geol. Mag. [3] vol. v. p. 509.
Egerton Coll.

(iii.) Tynet Burn (typical *P. latus*).

37985. Imperfect head and trunk, displaying several plates.
Purchased, 1863.

44587. Crushed remains of head and trunk, portions showing the ornamentation of closely-arranged rounded tubercles.
Purchased, 1873.

35981. Imperfect individual, wanting almost the whole of the tail. A few of the head-plates and the operculum (or extra-lateral) are well displayed, the latter being shown in Pl. V. fig. 6. The hinder edge of the posterior ventro-lateral plates of the trunk is coarsely denticulated.
Purchased, 1861.

35980. Crushed remains of armour of trunk, with the anterior median dorsal plate showing its overlapped postero-lateral border (Pl. V. fig. 7). *Purchased*, 1861.

(iv.) Gamrie (typical *P. quadratus*).

28856. Ventral plates of small trunk, visceral aspect.
Purchased, 1854.

28860. Imperfect specimen as large as the type, ventral aspect, with right pectoral appendage. *Purchased*, 1854.

50005. Small trunk, ventral aspect, showing portions of the tubercular ornament; the tubercles displayed are stellate.
Trevelyan Bequest.

P. 663–4, P. 3205–7, P. 3209. Seven split nodules, each with an imperfect specimen in counterpart, five exhibiting the ventral aspect, the sixth the dorso-lateral, and the seventh the dorsal. The tuberculations of the dermal plates are often shown; and in the last-mentioned specimen fine tubercles are seen upon the caudal scales.
Egerton & Enniskillen Colls.

28856 e. Trunk, with fragments of head and appendages, ventral aspect. *Purchased*, 1854.

47868. Crushed individual, ventral aspect, wanting the greater portion of the tail. *Purchased*, 1877.

47869. Much crushed and broken individual, dorsal aspect.
Purchased, 1877.

P. 4035. Crushed individual, ventral aspect, in counterpart, with traces of dorsal fin. *Purchased*, 1883.

P. 4036. Much crushed individual, lateral aspect, in counterpart, shown, of the natural size, in Pl. V. fig. 5. The head is almost wanting, but some of the plates of the trunk are

distinguishable, and the tail is well shown. The caudal scales are externally tuberculated and deeply overlapping; and the dorsal ridge-scales (*f.*) beyond the fin are very distinct. The impression of one large fulcral scale is seen upon the anterior margin of the dorsal fin (*d.*).

Purchased, 1883.

Pterichthys testudinarius, Agassiz.

[Plate V. fig. 8; Plate VI. fig. 1.]

1844. *Pterichthys cornutus* and *P. testudinarius*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 302 (names only).
1844. *Pterichthys testudinarius*, L. Agassiz, Poiss. Foss. V. G. R. p. 14, pl. iv. figs. 1–3.
1844. *Pterichthys cornutus*, L. Agassiz, *ibid.* p. 17, pl. ii. figs. 1–5. [British Museum.]
1848. *Pterichthys testudinarius*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iv. p. 312.
1848. *Pterichthys cornutus*, Sir P. Egerton, *ibid.* p. 313.
1855. *Pterichthys testudinarius*, F. M'Coy, Brit. Palæoz. Foss. p. 600.
1888. *Pterichthys cornutus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 509, and Ann. Mag. Nat. Hist. [6] vol. ii. pl. xvii. figs. 1–3.

Type. Head and trunk; Edinburgh Museum.

Inferior surface of carapace narrowly ovate; tail about equal in length to the trunk. Pectoral appendages less than two-thirds as long as the trunk, not expanded, tapering.

Form. & Loc. Lower Old Red Sandstone: Lethen Bar, Nairnshire.

P. 3202. One of the type specimens of *P. cornutus*, figured by Agassiz, *op. cit.* pl. iv. fig. 2. *Enniskillen Coll.*

P. 548, P. 3203. One of the type specimens of *P. cornutus*, in counterpart, figured *ibid.* fig. 4.

Egerton & Enniskillen Colls.

P. 549, P. 3201. One of the type specimens of *P. cornutus*, in counterpart, figured *ibid.* fig. 5.

Egerton & Enniskillen Colls.

28857 a. Ventral plates of trunk, visceral aspect, with right pectoral appendage and remains of tail. *Purchased*, 1854.

49190. Trunk, ventral aspect, wanting the tail, with displaced head and scattered plates of the carapace. The greater portion of the specimen is shown, of the natural size, in Pl. V. fig. 8, and the various plates are indicated by the lettering. *Purchased*, 1878.

P. 655. Much crushed, imperfect specimen. *Egerton Coll.*

P. 655 a. Small specimen, wanting head. *Egerton Coll.*

P. 5053. Small specimen, in counterpart, scarcely crushed, wanting the head. The half exhibiting the ventral plates from the visceral aspect is shown, of the natural size, in Pl. VI. fig. 1. The various elements are indicated by the lettering, and some of the overlapping margins of the plates are well seen. *Presented by J. E. Lee, Esq.*, 1885.

Pterichthys productus, Agassiz.

[Plate V. fig. 9 ; Plate VI. fig. 2.]

1844. *Pterichthys productus* and *P. cancriformis*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 302 (names only).
1844. *Pterichthys productus*, L. Agassiz, Poiss. Foss. V. G. R. p. 16, pl. v. figs. 1–4.
1844. *Pterichthys cancriformis*, L. Agassiz, *ibid.* p. 17, pl. i. figs. 4, 5. [British Museum.]
1848. *Pterichthys productus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iv. p. 312.
1855. *Pterichthys cancriformis*, F. M'Coy, Brit. Palæoz. Foss. p. 509.
1855. *Pterichthys productus*, F. M'Coy, *ibid.* p. 600.
1880. *Pterichthys*, J. Lahusen, Verhandl. russ.-kais. mineral. Gesell. [2] vol. xv. pl. ii. fig. A.
1888. *Pterichthys productus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 509.

Type. Imperfect individuals, ventral aspect; British Museum and Forres Museum.

Inferior surface of carapace narrowly ovate; tail about equal in length to the trunk. Pectoral appendages about two-thirds as long as the trunk, the distal segment considerably expanded.

Form. & Loc. Lower Old Red Sandstone : Nairnshire, Banffshire, Ross-shire, and Orkney.

(i.) Lethen Bar.

P. 534, P. 3212. One of the type specimens, in counterpart, figured by Agassiz, *op. cit.* pl. v. fig. 1. The fossil exhibits the ventral aspect of the head and trunk and right pectoral appendage, much broken, and is re-figured in Pl. V. fig. 9, with explanatory lettering. *Egerton & Enniskillen Colls.*

P. 547. Counterpart of one of the type specimens figured by Agassiz, *op. cit.* pl. v. fig. 2. *Egerton Coll.*

28859, 39175. Much crushed individual, in counterpart, exhibiting the lateral and partly dorsal aspect. The elements of the head are almost unrecognizable, and those of the trunk and appendages are imperfectly displayed. The dorsal fin upon the tail is distinct, with remains of its fulcral scale; and more posteriorly is observed the series of large dorsal ridge-scales.

Purchased, 1854, *and Bowerbank Coll.*

49188. Head, trunk, appendages, and fragment of tail, ventral aspect, preserved in counterpart. In the head, the "os dubium" or pineal plate, with its central pit, is well shown.

Purchased, 1878.

50108. Large specimen wanting the tail and the extremities of the appendages. The trunk measures 0·078 in length, exhibiting the ventral aspect, and the roof-plates of the head are seen from beneath. Most of the latter are well shown, and as their substance is partly destroyed, the course of the sensory canal upon the laterals and premedian can be traced. The extra-laterals are detached.

Purchased, 1879.

50111. Well-preserved specimen, ventral aspect, in counterpart, the impression shown of the natural size in Pl. VI. fig. 2, and explained by the lettering. The tail is somewhat twisted, thus exhibiting the dorsal fin. *Purchased*, 1879.

50113. Small specimen, wanting the tail, ventral aspect.

Purchased, 1879.

P. 3211. Much crushed specimen, ventral aspect, wanting appendages. *Enniskillen Coll.*

P. 4037. Small head and trunk, ventral aspect, in counterpart.

Purchased, 1883.

(ii.) Tynet Burn.

44588. Small imperfect crushed specimen, ventral aspect.

Purchased, 1873.

(iii.) Edderton, near Tain.

P. 1172. Much crushed and broken individual. *Egerton Coll.*

(iv.) Orkney (typical *P. cancriformis*).

P. 532. One of the type specimens of *P. cancriformis* figured by

Agassiz, *op. cit.* pl. i. fig. 4. The trunk is seen from the ventral aspect, but its correct outline is apparently destroyed. *Egerton Coll.*

P. 3208 a. Second type specimen of *P. cancriformis*, figured *ibid.* fig. 5. *Enniskillen Coll.*

34987–89. Two large specimens exhibiting the tail, and one small specimen. *Purchased*, 1860.

35047. Imperfect large specimen; Stromness. *Purchased*, 1860.

38731–32. Small specimen and portion of larger individual. *Purchased*, 1865.

41998. Comparatively well preserved specimen, ventral aspect, showing displaced mental plates; Stromness. *Purchased*, 1870.

P. 660–2. Small distorted specimen and two more imperfect larger examples; Belyacreugh. Also a fragment, with pectoral appendages, from Ramna Gio. *Egerton Coll.*

P. 3208. Two specimens, ventral aspect. *Enniskillen Coll.*

Pterichthys oblongus, Agassiz.

[Plate V. fig. 10; Plate VI. figs. 3, 4.]

1844. *Pterichthys oblongus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 302 (name only).
1844. *Pterichthys oblongus*, L. Agassiz, Poiss. Foss. V. G. R. p. 18, pl. iii. figs. 1, 2.
1848. *Pterichthys oblongus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iv. p. 313.
1855. *Pterichthys oblongus*, F. M'Coy, Brit. Palæoz. Foss. p. 600.
1888. *Pterichthys oblongus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 509.

Type. Imperfect trunk and tail, ventral aspect; Elgin Museum.

Inferior surface of carapace long and narrow, sides nearly straight; tail shorter than the trunk. Pectoral appendages less than two thirds as long as the trunk, the distal segment considerably expanded.

Form. & Loc. Lower Old Red Sandstone: Banffshire, Nairnshire, and Cromarty.

(i.) Gamrie.

28856 a. Imperfect specimen, ventral aspect, in counterpart. *Purchased*, 1854.

28856 b. Imperfect specimen, ventro-lateral aspect, in counterpart. *Purchased*, 1854.

28856 c. Small trunk, ventral aspect, with portions of appendages. *Purchased*, 1854.

34991. Ventral plates, visceral aspect, and other fragments. *Purchased*, 1860.

50006. Remains of small head and trunk, ventral aspect. *Purchased*, 1878.

37767. Small specimen, ventral aspect, wanting head and left pectoral appendage. *Purchased*, 1863.

P. 664 a, P. 3209 a. Crushed and broken individual, ventral aspect, in counterpart, shown, of the natural size, in Pl. VI. fig. 3. The head is wanting, and only portions of the appendages are preserved. The tubercular ornament is seen not only upon the plates of the trunk and appendages, but also upon the caudal scales. The dorsal fin (*d.*) occurs somewhat displaced; the dorsal ridge-scales (*f.*) towards the extremity of the tail are distinct; and remains of the large lower lobe of a caudal fin (*x.*) are also conspicuous. *Egerton & Enniskillen Colls.*

P. 663–4, P. 3209. Head and trunk, dorso-lateral aspect, in counterpart, and a smaller specimen, ventral aspect, also in counterpart. *Egerton & Enniskillen Colls.*

P. 3210. Two imperfect specimens, ventral aspect. *Enniskillen Coll.*

28856 d. Crushed and broken trunk, ventral aspect. *Purchased*, 1854.

(ii.) Lethen Bar.

30875. Remains of trunk and right pectoral appendage, ventral aspect. *Purchased*, 1856.

39174. Imperfect specimen, ventral aspect, displaying expansion of the left pectoral appendage, as shown in Pl. V. fig. 10. *Bowerbank Coll.*

40323. Imperfect specimen, wanting tail, ventral aspect, in counterpart. *Purchased*, 1867.

40324. Much crushed and broken specimen, ventral aspect, showing expansion of pectoral appendage. *Purchased*, 1867.

48163. Trunk and portions of head and tail, ventral aspect, in counterpart. The displaced "os dubium" is shown, and one of the orbital plates is exhibited in the dorsal opening of the head. *Purchased*, 1877.

49189. Small individual with imperfect head and tail, ventral aspect, in counterpart. The left extra-lateral plate is seen displaced; the expansion of the pectoral appendages is distinct; and two or three of the dorsal ridge-scales upon the tail are exhibited. *Purchased*, 1878.

50107. Imperfect head and trunk, ventral aspect, in counterpart, shown, of the natural size, in Pl. VI. fig. 4. In the orbital opening, the "os dubium" (*p.*) and the two orbital plates are exhibited. The left pectoral appendage displays the characteristic distal expansion. *Purchased*, 1879.

50108. Crushed individual, wanting extremities of appendages, ventral aspect. The tubercular ornamentation of the ventral plates is well shown in impression. *Purchased*, 1879.

50112. Imperfect crushed trunk with right pectoral appendage, remains of the head, the greater portion of the tail and dorsal fin. *Purchased*, 1879.

P. 657. Two imperfect specimens, ventral aspect, one displaying the left pectoral appendage. *Egerton Coll.*

P. 6071. Ventral plates of trunk, fragments of left pectoral appendage and tail. *Presented by F. Harford, Esq.*, 1889.

P. 4038. Trunk 0·035 in length, with portions of appendages and tail, ventral aspect, in counterpart, probably young of this species. *Purchased*, 1883.

(iii.) Tynet Burn.

37781. Much crushed trunk, ventro-lateral aspect, showing left pectoral appendage and fragments of head and tail. The tubercular ornamentation is well displayed. *Purchased*, 1863.

35979. Large specimen, ventral aspect, doubtfully of this species. The displaced mental plates are seen from their concave visceral aspect; the internal transverse ridge upon the anterior ventro-laterals is distinct; and the tubercular

ornament both of the ventral plates and caudal scales is shown in impression. *Purchased*, 1861.

(iv.) Cromarty.

19052, 19055, 19059. Three imperfect examples of the trunk, ventral aspect, the first also showing traces of the tail, and the third, of the head. *Purchased*, 1845.

19804 a. Imperfect specimen displaying the inner aspect of the dorso-lateral and median dorsal plates, and characteristic portions of the expanded appendages. In the orbital opening the "os dubium" is distinctly separated from the right orbital plate, and there is a trace possibly of an anterior plate in advance of the former. The scales of the tail are observed to be tuberculated. *Purchased*, 1845.

47870. Much crushed trunk and appendages, in counterpart, showing ornamentation. *Purchased*, 1877.

Pterichthys rhenanus, Beyrich.

1855. *Physichthys hoeninghausi*, H. von Meyer (*errore*), Palæontogr. vol. iv. p. 80, pl. xv. fig. 7. [Anterior median dorsal plate; Cambridge Museum, Mass.]

1877. *Pterichthys rhenanus*, E. Beyrich, Zeitschr. deutsch. geol. Gesell. vol. xxix. p. 751, pl. x.

Type. Dermal armour of trunk; Berlin Museum.

Inferior surface of carapace broadly ovate. Anterior median dorsal plate as broad as long, extremely elevated, the longitudinal ridge bent at a right angle slightly behind the middle point; posterior median dorsal plate two thirds as long as the anterior median.

Form. & Loc. Devonian: Gerolstein, Eifel.

Not represented in the Collection.

Dermal plates of Antiarcha (and probably other Chordate types), too imperfect for satisfactory determination, have also been assigned to *Pterichthys* under the following names:—

Pterichthys arenatus, L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 133, pl. xxx. *a*. fig. 3.—Devonian; St. Petersburg.

Pterichthys cellulosus, C. H. Pander in A. von Keyserling, Reise in das Petschoraland (1846), p. 292 *a*.—Devonian; Petchora Land, N.E. Russia.

Pterichthys elegans, C. H. Pander, Monogr. Foss. Fische Silur.

Syst. (1856), p. 63, pl. v. fig. 10.—Upper Silurian; Baltic Provinces[1].

Pterichthys harderi, C. H. Pander, *ibid.* p. 63, pl. v. fig. 9.—Upper Silurian; Baltic Provinces[1].

Pterichthys striatus, C. H. Pander, *ibid.* p. 63, pl. v. fig. 11.—Upper Silurian; Baltic Provinces. [Not *Pterichthys*.]

Genus **MICROBRACHIUM**, Traquair.

[Geol. Mag. [3] vol. v. 1888, p. 510.]

Form and proportions of head and trunk as in *Bothriolepis*, but pectoral appendages relatively small. The anterior median dorsal plate very broad; "its antero-lateral margin on each side first envelops the anterior dorso-lateral, and is then overlapped by it, the relation of the plates to each other being thus suddenly reversed; behind this the postero-lateral and posterior margins of the plate are overlapped by the posterior dorso-lateral and the posterior dorso-median. The last-mentioned plate shows posteriorly a prominent angular point, projecting over the hinder opening of the carapace." (*Traquair.*)

A single small species, not represented in the Collection, is described thus:—

Microbrachium dicki, R. H. Traquair, Geol. Mag. [3] vol. v. (1888), p. 510, and Ann. Mag. Nat. Hist. [6] vol. ii. (1888), p. 502, pl. xviii. figs. 7, 8: *Pterichthys dickii*, C. W. Peach, Rep. Brit. Assoc. 1867 (1868), Trans. Sect. p. 72 (name only).—Lower Old Red Sandstone; John-o'-Groats, Caithness. [Edinburgh Museum.]

Genus **BOTHRIOLEPIS**, Eichwald.

[Bull. Sci. St.-Pétersbourg, vol. vii. 1840, p. 79.]

Syn. *Pamphractus*, L. Agassiz, Poiss. Foss. V. G. R. 1844, pp. 5, 20.
Placothorax, L. Agassiz, *ibid.* 1845, p. 134.
Homothorax, L. Agassiz, *ibid.* 1845, p. 134.
Glyptosteus, L. Agassiz, Poiss. Foss. vol. i. 1844, p. xxxiv (name only).
Stenacanthus, J. Leidy, Proc. Acad. Nat. Sci. Philad. vol. viii. 1857, p. 11.

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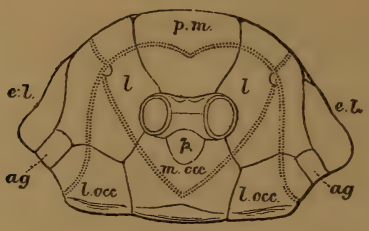
[1] These species are regarded as possibly founded upon fragments of *Asterolepis ornata* by E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1507.

Head and trunk broad, depressed, the scutes ornamented with tubercles partially or completely fused into a network of ridges; tail [if present] without dermal armature. Lateral sensory canals on the upper aspect of the head united by two transverse commissures arising from a point on the lateral plates, the anterior directly

Fig. 34.



Head of *Bothriolepis canadensis*, Whit.—Dorsal aspect, restored by R. H. Traquair. *ag*, angular; *e.l*, extra-lateral (operculum); *l*, lateral; *l.occ*, lateral occipital; *m.occ*, median occipital; *p*, postmedian; *p.m*, premedian.

crossing the premedian, the posterior arched backwards, its right and left halves meeting in a sharp angulation upon the median occipital; anterior median dorsal plate overlapping the anterior dorso-lateral and overlapped by the posterior dorso-lateral, the two halves of a commissure arising from the lateral sensory canals on the posterior dorso-lateral plates meeting in an acute angle about the middle of its surface. Pectoral appendages at least as long as the armoured trunk, segmented into a distal and proximal portion, the latter being much larger than the former; marginal scutes of proximal portion meeting mesially, with a minute "anconeal" element only on the dorsal aspect; marginal and central scutes of distal portion more numerous than in *Pterichthys*.

The form and arrangement of the bones occupying the orbital opening of this genus have been discovered and described in detail by Whiteaves[1]. The present writer has had the privilege of examining the original specimens of the Canadian species elucidating the points made known, and is thus able to confirm all the determinations. The arrangement is very similar to that described above in *Pterichthys* (p. 210); but additional information as to the precise form of the narrow, transversely-elongated plate in front of the pineal element is afforded thus:—"The central portion of the little plate is continued downward at nearly a right angle, as a narrow

[1] Trans. Roy. Soc. Canada, vol. iv. sect. iv. (1887), p. 102, pl. vi.

linear process, less than 0·001 in breadth, and about 0·004 in length; after which it widens, at a right angle to the longer axis of the body, into a small and narrowly pentangular expansion about 0·002 broad and 0·003 in length, which reaches nearly as far as the inner surface of the anterior ventral plates, though these are very much crushed upwards."

Bothriolepis ornata, Eichwald.

1840. *Bothryolepis prisca,* E. Eichwald, Neues Jahrb. p. 425 (name only).
1840. *Bothriolepis ornatus,* E. Eichwald, Bull. Sci. St.-Pétersbourg, vol. vii. p. 79.
1844. *Glyptosteus reticulatus,* L. Agassiz, Poiss. Foss. vol. i. p. xxxiv (name only), in part.
1845. *Bothriolepis ornatus,* L. Agassiz, Poiss. Foss. V. G. R. p. 99 (in part), pl. xxix. figs. 1, 2 (*non* figs. 3–5).
1857. *Asterolepis,* C. H. Pander, Placoderm. devon. Syst. p. 44.
1860. *Bothriolepis ornata,* E. von Eichwald, Leth. Rossica, vol. i. p. 1513, pl. lvi. fig. 3.
1880. *Bothriolepis ornata,* J. Lahusen, Verhandl. russ.-kais. mineral. Gesell. [2] vol. xv. p. 136.
1888. *Bothriolepis ornatus,* R. H. Traquair, Geol. Mag. [3] vol. v. p. 509.

Type. Anterior median dorsal plate; University of St. Petersburg.

The type species, of considerable size. Anterior median dorsal plate longer than broad, faintly carinated, ornamented with large pittings, due to the complete fusion of the tubercles; no distinct stellate tubercles.

Form. & Loc. Devonian: N.W. Russia.

P. 710. Imperfect anterior median dorsal plate and other fragments; Prikscha, Government of Novgorod. *Egerton Coll.*

P. 4600. Imperfect proximal marginal plate of appendage; Prikscha. *Enniskillen Coll.*

43452 a. Fragments of plates; Prikscha. *Presented by Kenneth Murchison, Esq.,* 1872.

Bothriolepis panderi, Lahusen.

1880. *Bothriolepis panderi,* J. Lahusen, Verhandl. russ.-kais. mineral. Gesell. [2] vol. xv. p. 125, pls. i., ii.
1880. *Bothriolepis panderi,* H. Trautschold, Bull. Soc. Imp. Nat. Moscou, pt. ii. p. 169, pl. ii.

1888. *Bothriolepis panderi*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. ii. p. 495.

Type. Imperfect head and trunk; School of Mines, St. Petersburg.

A species scarcely smaller than the type, the head attaining a breadth of 0·095, and much broader than long. Anterior median dorsal plate almost as broad as long, faintly keeled posteriorly. Ornamentation consisting of large stellate tubercles usually fused into vermiculating ridges.

Form. & Loc. Devonian: River Ssjass, Govt. of St. Petersburg.

P. 4490, 4490 a. Articular portion of large anterior ventro-lateral plate, and a similar smaller fossil. *Purchased*, 1884.

P. 4492. Portion of dorso-lateral plate. *Purchased*, 1884.

Bothriolepis major (Agassiz).

[Plate VI. figs. 5–8.]

1844. *Glyptosteus reticulaust*, L. Agassiz, Poiss. Foss. vol. i. p. xxxiv (name only), in part.

1844. *Pterichthys major*, L. Agassiz, Poiss. Foss. V. G. R. pp. 5, 19, 133, pl. xxxi. figs. 1–3.

1845. *Bothriolepis ornatus*, L. Agassiz (*errore*), *ibid.* pl. xxix. figs. 3–5. [Brit. Mus. No. 28873.]

1845. *Placothorax paradoxus*, L. Agassiz, *ibid.* p. 134, pl. xxx. *a.* figs. 20–23. [Portions of pectoral appendages; collection of James Powrie, Esq.]

1860. *Asterolepis major*, E. von Eichwald, Leth. Rossica, vol. i. p. 1511.

1880. *Bothriolepis major*, J. Lahusen, Verhandl. russ.-kais. mineral. Gesell. [2] vol. xv. p. 136.

1888. *Bothriolepis major*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 510, and Ann. Mag. Nat. Hist. [6] vol. ii. p. 501.

1888. *Bothriolepis giganteus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 510, and Ann. Mag. Nat. Hist. [6] vol. ii. p. 504, pl. xviii. fig. 3. [Brit. Mus. No. 28873.]

Type. Proximal plates of pectoral appendage; Geological Society of London.

An imperfectly known species, of moderate or large size. Tubercles upon dermal plates nearly always confluent, though often displaying indications of the original stellate bases. Proximal segment of pectoral appendage long and slender.

The so-called *Bothriolepis giganteus* is now regarded by Traquair (*in litt.*) as the adult of this species.

Form. & Loc. Upper Old Red Sandstone: Elgin. Devonian: N.W. Russia.

38717. External and internal cast of an imperfect cranial shield; Alves, near Elgin. A plaster cast taken from the impression of the outer surface is shown, of the natural size, in Pl. VI. fig. 5, with explanatory lettering.
Purchased, 1864.

35995 a. Portion of median occipital, showing characteristic sensory canals (Pl. VI. fig. 6); Scat Craig. *Purchased*, 1861.

35995 b. Median ventral plate; Scat Craig. *Purchased*, 1861.

35988–91. Four proximal portions of articular bones of pectoral appendages; Scat Craig. *Purchased*, 1861.

P. 4719 a. Portion of anterior ventro-lateral plate, with fragments of the two articular bones in position; Scat Craig.
Purchased, 1884.

P. 4719 b. Three imperfect dermal plates; Scat Craig.
Purchased, 1884.

P. 5095. Articular portion of anterior ventro-lateral, and detached proximal end of articular bone of appendage; Scat Craig.
Presented by John Edward Lee, Esq., 1885.

35995 c. Four plates of appendages, including the terminal; Scat Craig. One of the more proximal elements is shown, in outer view and transverse section, in Pl. VI. figs. 7, 7 *a*, while another, a distal marginal, is similarly represented, *ibid.* figs. 8, 8 *a*. *Purchased*, 1861.

28873. The three type specimens of *B. giganteus*, Traquair, figured by Agassiz, under the name of *Bothriolepis ornatus*, *loc. cit.*; Alves, near Elgin. Fig. 3 appears to represent a portion of a lateral head-plate; fig. 4, an imperfect ventro-lateral; and fig. 5, an imperfect dorso-lateral. *Purchased*, 1854.

28874. Six similar impressions of dermal plates, very imperfect; Alves. *Purchased*, 1854.

28874 a. Fragment of plate; Alves. *Purchased*, 1854.

38718. Impression of small, ridged plate; Alves. *Purchased*, 1864.

Remains of a species of *Bothriolepis* from the Heads of Ayr, originally associated with *B. major* by Traquair, are now regarded by the same author as representing a distinct species, *B. leptocheirus*, characterized by the length and slenderness of the appendages (to be described in Proc. Roy. Phys. Soc. Edinb., according to Traquair *in litt.*).

Bothriolepis obesa, Traquair.

1888. *Bothriolepis obesus,* R. H. Traquair, Geol. Mag. [3] vol. v. p. 510.

Type. Detached plates of trunk; Edinburgh Museum.

An imperfectly known species, of large size. Anterior median dorsal plate carinate; posterior dorso-lateral relatively short and deep; posterior ventro-lateral with relatively high ascending lamina. Ornamentation consisting of large, partially fused tubercles.

Form. & Loc. Upper Old Red Sandstone: Rule Water, near Jedburgh.

Not represented in the Collection.

Bothriolepis canadensis, Whiteaves.

1880. *Pterichthys* (*Bothriolepis*) *canadensis,* J. F. Whiteaves, Amer. Journ. Sci. [3] vol. xx. p. 135, and Canadian Naturalist, n. s. vol. x. pp. 26, 28.

1885. *Bothriolepis canadensis,* E. D. Cope, Amer. Nat. vol. xix. p. 290, woodc.

1887. *Pterichthys* (*Bothriolepis*) *canadensis,* J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. iv. sect. iv. p. 101, pls. vi.–ix.

1888. *Bothriolepis canadensis,* R. H. Traquair, Geol. Mag. [3] vol. v. p. 509, and Ann. Mag. Nat. Hist. [6] vol. ii. p. 496, pl. xviii. fig. 6.

1889. *Bothriolepis canadensis,* J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 91.

Type. Nearly complete individual; Geol. Survey of Canada, Ottawa.

A species of moderate size, the head and trunk attaining a length of about 0·17. Head much broader than long, about one half as long as the dorsal carapace of the trunk; trunk broadly ovate, the sides overhanging the narrowly ovate ventral surface. Proximal segment of pectoral appendages broad, but elongated; distal segment relatively slender, only slightly ornamented, two thirds as long as the proximal segment; outer and inner margins coarsely serrated. Anterior median dorsal plate as broad as long, more or less keeled in its posterior two thirds; posterior median dorsal plate longitudinally keeled, the keel rising to a slight eminence near the posterior margin. Ornament consisting of fine rounded tubercles fused into nodose, vermiculating ridges; those near the edges of the dorsal plates often directed mainly at right angles to the margins.

Form. & Loc. Upper Devonian: Scaumenac Bay, Province of Quebec, Canada.

The following specimens were collected by Mr. Jex, and, unless otherwise stated, were obtained by purchase, through Mr. R. Damon, 1888–89.

P. 5458-59. Two plaster casts of head and trunk, dorsal aspect, the second showing nearly complete appendages.

P. 5461. Dorsal plates of head, wanting the cover of the orbital opening.

P. 5462. Head and trunk, dorsal aspect, with well-preserved appendages.

P. 5463. Very large crushed specimen, dorsal aspect, wanting posterior median dorsal plate.

P. 5464. Smaller specimen, dorsal aspect, with imperfect appendages.

P. 5967. Imperfect specimen, dorsal aspect, 0·115 in length, with left appendage.

P. 5469. Dorsal aspect of trunk about equal in size to the last, with characteristic ornamentation.

P. 5968. Imperfect head and trunk, dorsal aspect, 0·1 in length.

P. 5473. Head and trunk, dorsal aspect, about 0·075 in length.

P. 5465. Very broad trunk, dorsal aspect, in counterpart, 0·04 in length, with hinder head-plates and imperfect appendages.

P. 5466. Very small similar specimen, in counterpart, the trunk 0·025 in length.

P. 5467–68. Scattered remains of large individual, and another specimen showing portions of the anterior ventro-lateral plates with the left appendage.

P. 5311. Crushed specimen, somewhat broken, ventral aspect.
Presented by A. H. Foord, Esq., 1887.

P. 5470. Much crushed and broken specimen, ventral aspect.

P. 5471. Trunk and appendages, ventral aspect, in counterpart.

P. 5472. Ventral plates of slightly smaller individual: the specimen seems to have been laterally compressed, thus causing the ventral armour to appear unusually narrow.

Bothriolepis hydrophila (Agassiz).

[Plate VI. fig. 9.]

1844. *Pamphractus hydrophilus*, L. Agassiz, Poiss. Foss. V. G. R. pp. 5, 21, pl. iv. figs. 4–7.

1844. *Pamphractus andersoni*, L. Agassiz, *ibid.* p. 21.

1845. *Homothorax flemingii*, L. Agassiz, *ibid.* p. 134, pl. xxxi. fig. 6.

1848. *Pterichthys hydrophilus*, H. Miller & Sir P. Egerton, Quart. Journ. Geol. Soc. vol. iv. pp. 312, 314.

1859. *Pamphractus andersoni*=*Pterichthys hydrophilus*, J. Anderson, Dura Den, pp. 49, 52, pl. i. fig. 1.

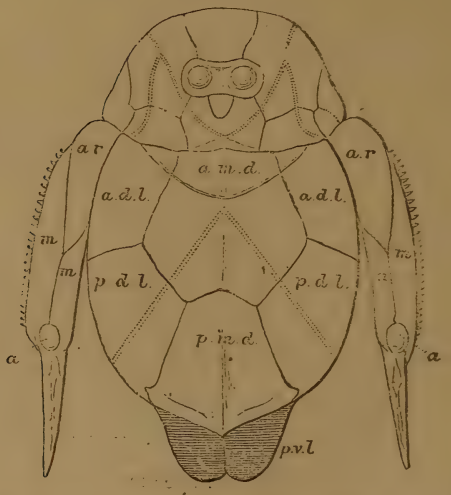
1862. *Pterichthys hydrophilus*, J. Powrie, Quart. Journ. Geol. Soc. vol. xviii. p. 435.

1888. *Bothriolepis hydrophilus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 510, and Ann. Mag. Nat. Hist. [6] vol. ii. p. 500, pl. xviii. figs. 4, 5.

Type. Imperfect individuals, dorsal aspect; Museum of Practical Geology.

A small species, the head and trunk attaining a length of about

Fig. 35.



Bothriolepis hydrophila (Ag.).—Dorsal aspect, restored by R. H. Traquair. *a.*, anconeal; *a.m.d.*, anterior median dorsal; *a.d.l.*, anterior dorso-lateral; *ar.*, articular; *m.*, marginal; *p.d.l.*, posterior dorso-lateral; *p.m.d.*, posterior median dorsal.

0·06–0·09. Form of head, trunk, and dorsal plates as in *B. canadensis*. Proximal segment of pectoral appendages broad, but elon-

gated, the outer margin with very large denticulations; distal segment relatively slender, only slightly ornamented, about half as long as the proximal segment. Ornament consisting of vermiculate anastomosing ridges, rarely distinctly nodose.

A restoration of the dorsal aspect of this species is given in the accompanying woodcut, fig. 35.

Form. & Loc. Upper Old Red Sandstone: Dura Den, Fifeshire.

26121. Small slab with three individuals, imperfectly preserved, ventral aspect. *Purchased*, 1851.

26121 a. Displaced anterior ventro-lateral plates, with bases of appendages, ventral aspect. The elements of the left side are shown, of the natural size, in Pl. VI. fig. 9: a portion of the bone is here broken away, displaying the transverse ridge (*r*) on the inner side of the anterior ventro-lateral, and showing no suture in this position. *Purchased*, 1851.

Bothriolepis macrocephala (Egerton).

1862. *Pterichthys macrocephalus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xviii. p. 103, pl. iii. figs. 7–9, woodc. figs. 1–3.

1888. *Bothriolepis macrocephalus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 510, and Ann. Mag. Nat. Hist. [6] vol. ii. p. 501.

Type. Imperfect individuals, dorsal and ventral aspect; British Museum.

A variety or species, so far as known, merely differing from the typical *B. hydrophila* in its much smaller size, the trunk only attaining an extreme length of 0·02.

Form. & Loc. Upper Old Red Sandstone: Farlow, Shropshire.

P. 606. First of the type specimens, dorsal aspect, figured by Egerton, *loc. cit.* fig. 7; Church Quarry, Farlow. *Egerton Coll.*

36442. Second type specimen, ventral aspect, wanting the head, figured *loc. cit.* fig. 8. *Purchased*, 1862.

P. 195. Third type specimen, being an impression of the anterior ventro-lateral plates, with part of one appendage, figured *loc. cit.* fig. 9. *Weaver-Jones Coll.*

P. 4599. Impression of anterior median dorsal plate. *Enniskillen Coll.*

36483. Ventral aspect of trunk and right appendage.
Purchased, 1862.

36464. Anterior ventro-laterals and imperfect appendages.
Presented by G. E. Roberts, Esq., 1862.

P. 196. Trunk and appendages, ventral aspect. *Weaver-Jones Coll.*

P. 197. Three portions of ventral plates, one being in counterpart.
Weaver-Jones Coll.

The two species mentioned below are founded upon anterior median dorsal plates, of which there are no examples in the Collection. The type specimens are preserved in the Museum of Columbia College, New York.

Bothriolepis leidyi, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 111, pl. xviii. fig. 2, pl. xx. figs. 1–5: *Stenacanthus nitidus*, J. Leidy, Proc. Acad. Nat. Sci. Philad. vol. viii. 1857, p. 11, and Journ. Acad. Nat. Sci. Philad. [2] vol. iii. (1856), p. 164, pl. xvi. figs. 7, 8. [Type of *Stenacanthus*, founded upon portion of pectoral appendage in Mus. Acad. Nat. Sci. Philad.] *Holoptychius americanus*, J. Leidy (in part, *errore*), *ibid.* 1856, p. 163, pl. xvii. fig. 4.—Catskill Group (Upper Devonian); Tioga Co., Pennsylvania.

Bothriolepis minor, J. S. Newberry, *op. cit.* (1889), p. 112, pl. xx. figs. 6–8.—Chemung Group (Upper Devonian); Bradford Co., Pennsylvania.

In the singular groups of detached plates of *Bothriolepis leidyi*, the large anterior median dorsal plate is more numerous than any of the others. This reminds the English palæontologist of the manner in which the shields of *Pteraspis* sometimes occur in groups in the Cornstones of Herefordshire—one group comprising all dorsals, another all ventrals. The last-named circumstance has sometimes been regarded as proof that the so-called "*Scaphaspis*" is not the ventral plate of *Pteraspis*; but in this case, as in that of the American *Bothriolepis*, the arrangement of the fossils is evidently due to drifting and assorting by currents of water during the deposition of the sediment.

Family CERASPIDÆ.

An imperfectly definable family, of uncertain position, known only by the detached dermal plates; these plates consisting of a very thick middle layer of cancellous tissue, an inner squamous layer, and a thin outer layer with a fine superficial ribbed ornament.

Genus **CERASPIS,** Schlüter.

[Sitzungsb. niederrhein. Ges. Bonn, 1887, p. 120.]

The type and only known genus. Body deep, with a sharp longitudinal dorsal ridge.

The structure of the shield suggested to Schlüter the association of this genus with the Pteraspidæ; but the examination of a large series of specimens in the Museum of Comparative Zoology, Cambridge, Mass., has led the present writer to refer the problematical fish to the Antiarcha. One specimen shows two much elevated azygous plates in direct apposition one behind the other, very similar in form and proportions to the median dorsal plates of *Pterichthys rhenanus*; the posterior plate, however, is relatively larger, has an especially deep keel, and seems to have been produced into a posterior horn. Another plate is very similar in form to a ventro-lateral of *Pterichthys*; and it may be added that, where thickened, the plates of the Asterolepidæ have an inner cancellated structure precisely similar to that observed in the fossils now under discussion.

Ceraspis carinata, Schlüter.

1887. *Ceraspis carinatus*, C. Schlüter, Sitzungsb. niederrhein. Ges. Bonn, p. 120.

1887. *Ceraspis hagenensis*, C. Schlüter, *ibid.* p. 122.

Type. Imperfect dermal plates; University Museum, Bonn.

The type species, of moderate size. The horn-like process of the hinder dorsal plate (*carinatus*) much laterally compressed, with smooth, flattened, longitudinal ribs, very closely arranged, sometimes intercalated and bifurcating. Anterior median dorsal plate (*hagenensis*) much longer than broad, with a sharp longitudinal median keel rising to an obtuse apex behind its middle point; the sides of the plate facetted and marked with fine ridges parallel to the outer border.

Form. & Loc. Middle Devonian: Eifel.

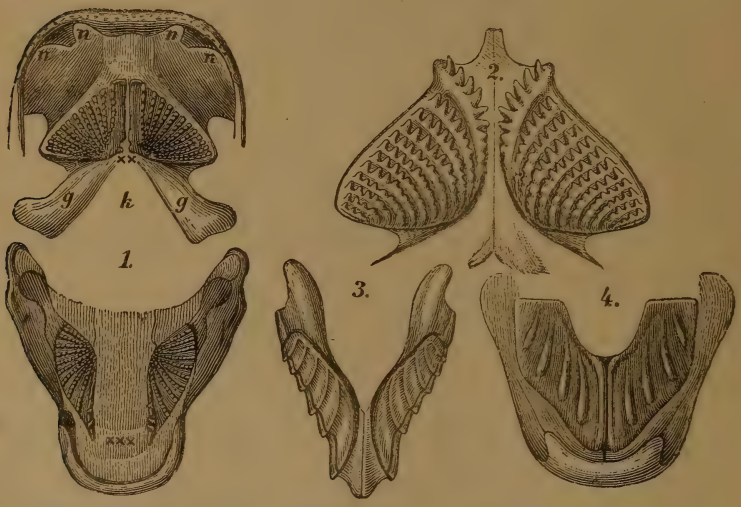
36160. Imperfect large horn-like plate, showing the superficial ribbed ornament above, and the inner cancellated tissue towards its base; Gerolstein. *Purchased*, 1861.

Subclass IV. DIPNOI.

Skeleton partially ossified, with numerous well-developed membrane bones. Upper mandibular arch confluent with the chondrocranium; gill-clefts feebly separated, opening into a cavity with external cover. Exoskeleton consisting of true bony tissue. In the living forms—optic nerves not decussating, bulbus arteriosus of the heart with series of valves, intestine with a spiral valve, and air-bladder lung-like.

The dermal or membrane bones of the cranial roof in this subclass exhibit little conformity with the arrangement almost invariably observed in the Teleostomi; and it seems impossible to apply to them the nomenclature adopted in the case of the latter subclass.

Fig. 36.



Dentition of extinct Dipnoi.—1. *Dipterus valenciennesi*, Sedgw. & Murch.; upper and lower jaws, nat. size. xx, upper dental plates; xxx, lower dental plates; *g*, upper dentigerous bones; *n*, narial openings. 2. *Ctenodus cristatus*, Ag.; upper dental plates (somewhat inaccurately drawn, the oral aspect being in reality concave), one-third nat. size. 3. *Sagenodus inæqualis*, Owen; lower dentition, one-half nat. size. 4. *Palædaphus insignis*, Van Ben. & De Kon.; lower dentition, one-sixth nat. size.

Order I. SIRENOIDEI.

Head with well-developed dermal or membrane bones; principal dentition consisting of triturating plates on the pterygoid and splenial elements. Dermal armour of trunk, when present, consisting of imbricating scales; no plates. Notochord persistent. Paired fins archipterygial; pelvic arch consisting of a single bilaterally-symmetrical cartilage.

Synopsis of Families.

A. Cranial roof-bones numerous.
   Jugular plates; no marginal teeth .. DIPTERIDÆ (p. 235).
   Jugular plates; marginal teeth..... PHANEROPLEURIDÆ (p. 246).
   No jugular plates; no marginal teeth. CTENODONTIDÆ (p. 250).
B. Cranial roof-bones few.
   No jugular plates; no marginal teeth. LEPIDOSIRENIDÆ (p. 264).

Family DIPTERIDÆ.

Cranial roof-bones numerous; no distinctly differentiated maxilla or premaxilla, and no marginal series of teeth above or below; jugular plates present. Caudal fin heterocercal. Scales cycloid.

The only sufficiently defined genus referable to this family is *Dipterus*.

Genus **DIPTERUS**, Sedgwick & Murchison.

[Trans. Geol. Soc. [2] vol. iii. 1828, p. 143.]

Syn. *Catopterus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. 1833, p. 3.
Polyphractus, L. Agassiz, Poiss. Foss. V. G. R. 1844, pp. 5, 29.

Body elongate, not much laterally compressed, covered with enamelled cycloid scales; head depressed, snout obtuse. Dental plates, above and below, triangular in shape, with outwardly radiating ridges, tuberculated or strongly crenulated. Paired fins acutely lobate; two remote dorsal fins opposed to the pelvic and anal fins, separated from the caudal.

The most complete account of the skeletal anatomy of *Dipterus*

is given by C. H. Pander [1] and R. H. Traquair [2]; and all the known species are of small size.

Dipterus valenciennesi, Sedgwick & Murchison.

1828. *Dipterus valenciennesii*, A. Sedgwick & R. I. Murchison, Trans. Geol. Soc. [2] vol. iii. p. 143, pl. xvi. figs. 1–3.
1828. *Dipterus macropygopterus*, Sedgwick & Murchison, *ibid.* p. 143, pl. xv. figs. 1–3. [Mus. Geological Society of London.]
1828. *Dipterus brachypygopterus*, Sedgwick & Murchison, *ibid.* p. 143, pl. xvii. figs. 1–3.
1833. *Catopterus analis*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 3.
1835. *Dipterus macrolepidotus*, L. Agassiz, *ibid.* p. 115, pl. ii. figs. 1–3, pl. ii. *a*. figs. 1–5.
1841. *Dipterus*, H. Miller, Old Red Sandstone, p. 79, pl. v. fig. 1.
1844. *Polyphractus platycephalus*, L. Agassiz, Poiss. Foss. V. G. R. pp. 5, 29, pl. xxvii. fig. 1, pl. xxxi. fig. 5. [Cranial shield; British Museum.]
1844. *Megalichthys priscus*, L. Agassiz, Poiss. Foss. vol. i. p. xxxiv (name only).
1849. *Dipterus*, H. Miller, Footprints of the Creator, p. 59, figs. 18–22.
1855. *Dipterus brachypygopterus*, *D. macropygopterus*, and *D. valenciennesii*, F. M'Coy, Brit. Palæoz. Foss. p. 592.
1858. *Dipterus valenciennesii*, C. H. Pander, Ctenodipt. devon. Syst. p. 6, pl. i. figs. 1–4, 8, pl. ii. figs. 1, 6, 7.
1858. *Dipterus platycephalus*, C. H. Pander, *ibid.* p. 7, pl. i. fig. 5, pl. ii. figs. 2, 9, pl. iii., pl. iv. figs. 23, 27, pl. v. figs. 15–19, pl. vii. figs. 5, 11.
1861. *Dipterus*, T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 14, fig. 10, woodc.
1871. *Dipterus*, A. Günther, Phil. Trans. p. 556, pl. xxxiv. fig. 4.
1878. *Dipterus*, R. H. Traquair, Ann. Mag. Nat. Hist. [5] vol. ii. p. 1, pl. iii. figs. 1–4.
1888. *Dipterus valenciennesii*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 507.

Type. Imperfect fishes; Geological Society of London.

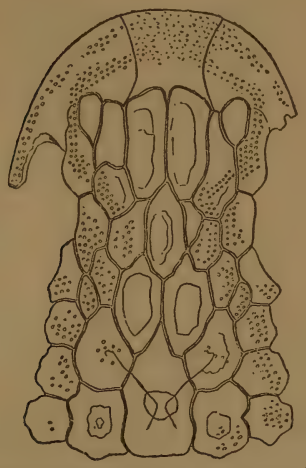
The type species, attaining a length of not less than 0·4. Head with opercular apparatus occupying somewhat more than one fifth of the total length; cranial shield very slightly tapering forwards, its maximum breadth at the occiput equalling about $\frac{2}{3}$ its total length, and the snout abruptly truncated, with rounded lateral angles; operculum trapezoidal, with slightly convex borders, as deep as broad; tuberculations of dental plates large, well separated, laterally

[1] Ueber die Ctenodipterinen des devonischen Systems, 1858, pp. 6–21, with plates.

[2] Ann. Mag. Nat. Hist. [5] vol. ii. (1878), pp. 1–12, pl. iii. figs. 1–4.

compressed and pointed, the apices being inclined outwards. Fins with prominent, narrow, scale-like fulcra; distance between the origin of the pelvic fins and the pectorals twice as great as that between the former and the anal; anterior dorsal fin situated slightly behind the pelvic pair, very small compared with the posterior dorsal, which is much elevated, its height being greater than

Fig. 37.



Dipterus valenciennesi, Sedgw. & Murch.—Cranial shield, after Pander.

the length of its base-line; anal fin acuminate, very deep and narrow, situated close to the lower lobe of the caudal. Scales thick and punctate, exhibiting only the concentric lines of growth.

Form. & Loc. Lower Old Red Sandstone: Caithness, Orkney Isles, Ross-shire, Cromarty, Nairnshire, and Banffshire.

P. 759-60. Plaster casts of two cranial bucklers, a palato-pterygoid, and an imperfect palate with dental plates; the originals in the Hugh Miller Collection, Edinburgh. *Egerton Coll.*

P. 6263. Plaster cast of palatal aspect of skull; Caithness. The original is preserved in the Museum of Practical Geology, Jermyn St., and is described and figured by A. Günther, Phil. Trans. 1871, p. 556, pl. xxxiv. fig. 4.

Made in the Museum.

33153, 33165, 33178. Three imperfect heads, displaying the upper aspect of the cranial buckler; Thurso. *Purchased*, 1857.

42403. Upper aspect of head, much crushed and broken; Kilminster, near Wick, Caithness. *Peach Coll.*

P. 755. Large abraded cranial buckler, upper aspect, and two smaller imperfect examples; Orkney. *Egerton Coll.*

P. 3373 a. Imperfect cranial buckler, upper aspect, showing concentric structure of the dermal plates; Orkney. This is the type specimen of *Polyphractus platycephalus*, Agassiz, *op. cit.* (1844) pl. xxvii. fig. 1. *Enniskillen Coll.*

P. 546. Operculum figured as *Polyphractus platycephalus* by Agassiz, *ibid.* pl. xxxi. fig. 5; Orkney. *Egerton Coll.*

33166. Anterior portion of skull, showing palatine dental plates; Thurso. *Purchased*, 1857.

42405. Right palatine tooth attached to supporting bone; Thurso. *Peach Coll.*

42404. Mandible seen in horizontal section in hard rock; Kilminster. *Peach Coll.*

36007. Imperfect fish, 0·25 in length, with portions of the pectoral and median fins; Tynet Burn, Banffshire. *Purchased*, 1861.

43270. Similar specimen, somewhat smaller, displaying large portions of both pectoral fins; Tynet Burn. *Purchased*, 1871.

20686–87, 20689–90. Four specimens showing more or less of the trunk and median fins; Caithness. The fourth specimen exhibits the two dorsal fins and a portion of the caudal, well exposed, with the distally branching rays. *Purchased*, 1847.

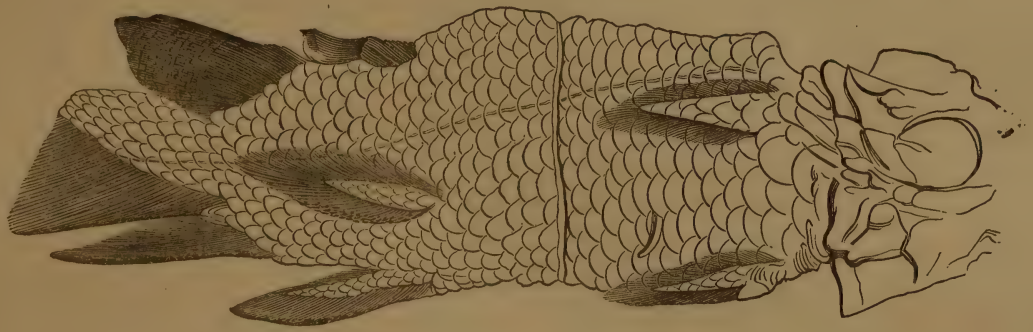
33149–52. Slab with portions of about six fishes, and four imperfect larger individuals; Thurso. *Purchased*, 1857.

33172. Remains of anterior half of fish; Holburn Head, Thurso. *Purchased*, 1857.

42480. Nearly complete small fish; Banniskirk, Caithness. *Peach Coll.*

P. 618. Small fish showing median and paired fins, figured in Murchison's 'Siluria,' ed. 3, p. 287, fig. 71, and by Huxley, *loc. cit.* 1861, the figure being reproduced in the accompanying woodcut (fig. 38); Banniskirk. *Egerton Coll.*

Fig. 38.



Dipterus valenciennesi, Sedgw. & Murch.—Outline of No. P. 618, showing lobate paired fins.

P. 756. Impression of a large crushed fish, and two portions of small individuals; Caithness. *Egerton Coll.*

P. 3374, P. 4597. The caudal half of two small individuals, and a mass of scales of a large fish; Caithness. *Enniskillen Coll.*

P. 3374 a. Incomplete small fish, probably of this species; Orkney. *Enniskillen Coll.*

19808. Small fish, either of this or the following species; Caithness. *Purchased*, 1845.

P. 3373. Imperfect small fish, probably of this species; Orkney. *Enniskillen Coll.*

P. 825. Scales, probably of this species; Edderton, near Tain, Ross-shire. *Egerton Coll.*

P. 1175. Remains of head and trunk, probably of this species; Edderton. *Egerton Coll.*

Dipterus macropterus, Traquair.

1888. *Dipterus macropterus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 508.

1889. *Dipterus macropterus*, R. H. Traquair, *ibid.* vol. vi. p. 97, pl. ii.

Type. Nearly complete fish; Edinburgh Museum.

A species usually attaining a length of about 0·2. Form and proportions of head and trunk as in the type species. Anterior dorsal fin relatively very small; posterior dorsal very large, much longer than high. Scales relatively thin.

Form. & Loc. Lower Old Red Sandstone: Caithness.

42473–78. Six specimens, four showing the nearly complete fish, the others also exhibiting several details of structure; John-o'-Groats. *Peach Coll.*

42479. Portion of axial skeleton and scales of a comparatively large fish; John-o'-Groats. *Peach Coll.*

The following species, being known only by detached dental plates, are doubtfully of this genus:—

Dipterus (?) serratus, Eichwald.

1844. *Ctenodus serratus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. p. 828.

1845. *Ctenodus keyserlingii*, L. Agassiz, Poiss. Foss. V. G. R. p. 122, pl. xxxiii. figs. 32–35.

1858. *Dipterus keyserlingii*, C. H. Pander, Ctenodipt. devon. Syst. pp. 22, 25 (? pl. vii. fig. 1).
1860. *Dipterus serratus*, E. von Eichwald, Leth. Rossica, vol. i. p. 1535.

Type. Dental plate.

Dental plate with numerous radiating ridges; tuberculations laterally compressed, almost imbricated, the pointed apices being inclined outwards.

Form. & Loc. Devonian: St. Petersburg, Russia.

P. 3375. Imperfect dental plate. *Enniskillen Coll.*

Dipterus (?) marginalis (Agassiz).

1845. *Ctenodus marginalis*, L. Agassiz, Poiss. Foss. V. G. R. p. 123, pl. xxviii. *a.* fig. 21 (*non* fig. 22) [1].
1858. *Dipterus marginalis*, C. H. Pander, Ctenodipt. devon. Syst. p. 24, pl. v. figs. 10–14, pl. vii. figs. 6, 7.
1860. *Dipterus marginalis*, E. von Eichwald, Leth. Rossica, vol. i. p. 1537.

Type. Dental plate.

A smaller species than *D. keyserlingii*, with the dental tuberculations less compressed, less imbricating, and more obtusely pointed; one margin and angle of the dental plate somewhat expanded, with slight concentric folds.

Form. & Loc. Devonian: St. Petersburg.

P. 757. Imperfect dental plate. *Egerton Coll.*

Dipterus (?) radiatus (Eichwald).

1844. *Ctenodus radiatus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. p. 827.
1845. *Ctenodus woerthii*, L. Agassiz, Poiss. Foss. V. G. R. p. 123, pl. xxxiii. fig. 36.
1858. *Dipterus radiatus*, C. H. Pander, Ctenodipt. devon. Syst. p. 22, pl. vii. figs. 8, 9.
1860. *Dipterus radiatus*, E. von Eichwald, Leth. Rossica, vol. i. p. 1536.

Type. Dental plate.

Dental tuberculations somewhat laterally compressed, well separated, obtusely pointed, and slightly inclined outwards.

Form. & Loc. Devonian: St. Petersburg.

19594. Dental plate; Ischora. *Purchased*, 1845.

[1] This figure is named "*Ctenodus asteriscus*, Ag.," by C. G. Giebel, Fauna der Vorwelt, Fische (1848), p. 343.

The following species have also been founded upon detached teeth, of which the majority may belong to this genus. They are not represented in the Collection.

Dipterus (*Ctenodus*) *flabelliformis*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 90, pl. xxvii. fig. 21.—Chemung Group; Warren, Pennsylvania. [Columbia College, New York.]

Dipterus glaber, C. H. Pander, Ctenodipt. devon. Syst. (1858), p. 29, pl. vii. fig. 10 (named *Dipterus* (*Cheirodus*?) *glaber* on plate).—Devonian; Ssjass, Govt. of St. Petersburg. [School of Mines, St. Petersburg.]

Dipterus (*Ctenodus*) *levis*, J. S. Newberry, *op. cit.* p. 90, pl. xxvii. figs. 22, 23.—Chemung Group; Warren, Pa. [Columbia College, New York.]

Dipterus (*Ctenodus*) *minutus*, J. S. Newberry, *ibid.* p. 91, pl. xxvii. fig. 26.—Chemung Conglomerate; Warren, Pa.

Dipterus murchisoni, C. H. Pander, *op. cit.* p. 23, pl. vii. figs. 2–4. —Devonian; Russia. [School of Mines, St. Petersburg.]

Dipterus (*Ctenodus*) *nelsoni*, J. S. Newberry, *op. cit.* p. 89, pl. xxvii. figs. 19, 20.—Chemung Group; Warren, Pa. [Columbia College, New York.]

Dipterus parvulus, L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 124, pl. xxviii. *a*. fig. 23 (*Ctenodus*); E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1537: *Dipterus tuberculatus*, C. H. Pander, *op. cit.* p. 22, pl. v. figs. 20–22.—Devonian; Russia.

Dipterus (*Ctenodus*) *radiatus*, J. S. Newberry (*non* Eichwald & Pander), *op. cit.* p. 119, pl. xxvii. fig. 33.—Catskill Group; Tioga Co., Pa.

Dipterus sherwoodi, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 61, pl. lviii. fig. 17, and *op. cit.* (1889), p. 118, pl. xxvii. fig. 3.—Catskill Group; Tioga Co., Pa. [Columbia College, New York.]

Dipterus verneuilli, C. H. Pander, *op. cit.* p. 21, pl. v. figs. 1–9; E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1538.—Devonian; Russia. [School of Mines, St. Petersburg.]

Indeterminable scales from the Devonian of the neighbourhood of St. Petersburg have also been named *Dipterus arenaceus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. (1844), p. 831, and *ibid.* vol. xix. (1846), p. 308, pl. x. figs. 31, 32, and Leth. Rossica, vol. i. (1860), p. 1540, pl. lvii. fig. 17.

An undetermined and imperfectly described jaw, from the Lower

Chemung Group of Ithaca, New York State, is named *Dipterus ithacensis*, H. S. Williams, Proc. Amer. Assoc. Adv. Sci. vol. xxx. (1881), p. 193.

Genus **PALÆDAPHUS,** P. J. Van Beneden & L. G. de Koninck.

[Bull. Acad. Roy. Belg. [2] vol. xvii. 1864, p. 150.]

Syn. *Heliodus*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. 1875, p. 62.

A provisional genus at present incapable of definition, comprising very large Palæozoic Dipnoan fishes, in which the anterior portion of the mandible resembles in shape that of *Dipterus*.

Palædaphus insignis, Van Beneden & de Koninck.

1864. *Palædaphus insignis*, P. J. Van Beneden & L. G. de Koninck, Bull. Acad. Roy. Belg. [2] vol. xvii. p. 143, pls. i., ii.
1871. *Palædaphus insignis*, A. Günther, Phil. Trans. p. 557.
1875. *Palædaphus insignis*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. p. 63.
1878. *Palædaphus insignis*, R. H. Traquair, Ann. Mag. Nat. Hist. [5] vol. ii. p. 12, pl. iii. figs. 5–7.
1888. *Palædaphus insignis*, A. Fritsch, Fauna der Gaskohle, vol. ii. p. 88, fig. 167.

Type. Anterior half of mandible with dental plates; Museum, University of Liége.

The type species. Mandibular dental plates attaining a length of about 0·13, with four rounded, widely-spaced, coronal ridges, scarcely radiating.

Form. & Loc. Upper Devonian: Belgium.

43603. Plaster cast of type specimen, shown, one sixth nat. size, in woodc. fig. 36 (4), p. 234; Huy. *Purchased*, 1872.

Palædaphus devoniensis, Van Beneden.

1869. *Palædaphus devoniensis*, P. J. Van Beneden, Bull. Acad. Roy. Belg. [2] vol. xxvii. p. 378, with plate.
1875. *Heliodus devoniensis*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. p. 63.
1878. *Palædaphus devoniensis*, R. H. Traquair, Ann. Mag. Nat. Hist. [5] vol. ii. p. 15.
1888. *Palædaphus devoniensis*, A. Fritsch, Fauna der Gaskohle, vol. ii. p. 89, fig. 168.

Type. Left palatine dental plate; Museum, University of Liége.

A species apparently larger than *P. insignis*. Palatine dental plates with not less than five widely-spaced, radiating, coronal ridges, coarsely crenulated.

Form. & Loc. Upper Devonian: Belgium.

43605. Plaster cast of type specimen.
Presented by Prof. P. J. Van Beneden, 1872.

Palædaphus lesleyi (Newberry).

1875. *Heliodus lesleyi*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. p. 64, pl. lviii. fig. 18.

1889. *Heliodus lesleyi*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi.), p. 86, pl. xviii. fig. 3.

Type. Upper dental plate; Columbia College, New York.

A species much smaller than either of the preceding, known only by a single example of the upper dental plate; characterized by eight coarsely crenulated or tuberculated coronal ridges, symmetrically radiating, and diminishing in size anteriorly and posteriorly.

This dental plate is regarded by Newberry as azygous, representing the ordinary pair of palatine plates, and is thus made the type of a distinct genus, *Heliodus*. The present writer considers that the specimen is a normal right or left palatine.

Form. & Loc. Upper Chemung Group: North Pennsylvania.

Not represented in the Collection.

A portion apparently of a very large dental plate, much resembling the palatine of *Palædaphus*, is described as *Archæonectes pertusus*, H. von Meyer, Palæontogr. vol. vii. (1859), p. 12, pl. ii. figs. 1, 2. The following is the type specimen:—

33596. Portion of dental plate with parts of four coronal ridges, and showing a large transversely oval foramen near the inner border; Devonian, Gerolstein. The specimen is regarded as the palatal region of a Dipnoan, wanting the dental plates, by A. Fritsch, Fauna der Gaskohle, vol. ii. (1888), p. 90, woodc. fig. 170. *Purchased*, 1859.

Also probably closely allied to *Palædaphus* is a Dipnoan fish from the Devonian of the Government of Orel, Russia, of which the fragmentary mandible was described under the name of *Holodus kiprijanowi* by C. H. Pander, Ctenodipt. devon. Syst. (1858), p. 38, pl. vi. figs. 1–14. In the original description the specimen is regarded as the anterior portion of the skull, and this determination is considered

plausible by A. Günther, Phil. Trans. 1871, p. 557, and A. Fritsch, Fauna der Gaskohle, vol. ii. (1888), p. 91; its reference to the mandible, however, seems more probably correct, as remarked by R. H. Traquair, Ann. Mag. Nat. Hist. [5] vol. ii. (1878), p. 15. Very similar also is an imperfect mandible, from an unknown formation and locality, named *Archæotylus ignotus*, H. von Meyer, Palæontogr. vol. xi. (1864), p. 285, pl. xliv.

Genus **CONCHODUS**, M'Coy.

[Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 312.]

Syn. *Cheirodus*, C. H. Pander (*non* M'Coy), Ctenodipt. devon. Syst. 1858, p. 33.

A provisional genus comprising species of small size, known only by the detached dental plates. Dental plates broad, thin, irregularly triangular, almost or quite smooth, with few short radiating ridges at the outer border.

Two species of this genus are recognized, but neither is represented in the Collection:—

Conchodus jerofejewi, C. H. Pander, Ctenodipt. devon. Syst. (1858), p. 61, pl. vi. figs. 15–22 (*Cheirodus*): *Ceratodus lateralis*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xix. (1846), pt. ii. p. 299 (name only): *Cheirodus lateralis*, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1542.—Devonian; N.W. Russia. [School of Mines, St. Petersburg.]

Conchodus ostreæformis, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 312, and Brit. Palæoz. Foss. (1855), p. 593, pl. ii. c. fig. 7.—Upper Old Red Sandstone; Scat Craig, Elgin. [The type species, founded upon a dental plate in the Woodwardian Museum, Cambridge.]

Genus **GANORHYNCHUS**, Traquair.

[Geol. Mag. vol. x. 1873, p. 555.]

A provisional genus at present incapable of definition, comprising large Palæozoic Dipnoan fishes in which the extremity of the snout (as also presumably all the external head-bones) is enveloped in a thick layer of punctate ganoine.

Ganorhynchus woodwardi, Traquair.

1873. *Ganorhynchus woodwardi*, R. H. Traquair, Geol. Mag. vol. x. p. 555, pl. xiv.

Type. Extremity of snout; British Museum.

The type species. Breadth of snout at anterior nares about 0·06; the inferior overturned margin very broad mesially, deeply notched by the narial openings laterally, flat, with few very coarse punctations, and large tubercles upon its posterior edge.

Form. & Loc. Unknown.

44627. Type specimen, incidentally mentioned under the name of *Megalichthys hibberti* by Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 91. *History unknown.*

A smaller rostrum than the type specimen of *G. woodwardi*, with a narrower inferior overturned margin and without lateral narial excavations, is described as *Ganorhynchus beecheri*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 95, pl. xix. fig. 2. This fossil was obtained from the Chemung Group (Upper Devonian) of Warren, Pennsylvania, and is now in the Museum of Columbia College, New York.

The following genera and species are also regarded by A. Fritsch as founded upon the dermal head-bones of Dipnoan fishes:—

Gompholepis panderi, J. Barrande, Syst. Silur. Bohême, vol. i. suppl. i. (1872), p. 644, pl. xxviii. figs. 1–3; A. Fritsch, Fauna der Gaskohle, vol. ii. (1888), p. 87, fig. 166, woodc.—Upper Silurian (Stage **G g 1**); Choteč, Bohemia. [Royal Bohemian Museum, Prague.]

Dipnoites perneri, A. Fritsch, Fauna der Gaskohle, vol. ii. (1888), p. 86, fig. 163, woodc.—Upper Silurian (Stage **G g 3**); Hlubočep, near Prague. [Royal Bohemian Museum.]

Family PHANEROPLEURIDÆ.

Cranial roof-bones numerous; margin of mouth, above and below, provided with a series of conical teeth; jugular plates present. Caudal fin diphycercal. Scales cycloid.

Synopsis of Genera.

Anal fin separate ..... *Phaneropleuron* (p. 247).
Anal fin continuous with caudal ..... *Uronemus* [1] (p. 249).

[1] Since these pages were in type, Dr. R. H. Traquair (Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 393) has expressed his opinion that *Uronemus* represents a distinct family, the Uronemidæ. The upper dental plates are stated to be replaced by mere granulations, but no details are as yet forthcoming.

Genus **PHANEROPLEURON,** Huxley.

[In Anderson's Dura Den, 1859, p. 67.]

Body laterally compressed, covered with very thin scales of moderate size; snout acute. Marginal teeth conical; dental plates with ridges of well-separated conical tubercles. Paired fins acutely lobate; dorsal fin single, arising in advance of the pelvic pair and continuous with the caudal; anal fin small, separate.

Phaneropleuron andersoni, Huxley.

1859. *Phaneropleuron andersoni,* T. H. Huxley, in J. Anderson's Dura Den, p. 67, pls. v., vi.

1861. *Phaneropleuron andersoni,* T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 47, pl. iii.

1862. *Phaneropleuron,* J. Powrie, Quart. Journ. Geol. Soc. vol. xviii. p. 434.

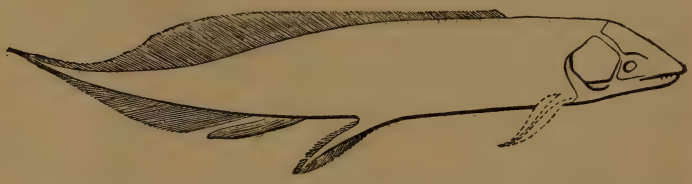
1872. *Phaneropleuron andersoni,* R. H. Traquair, Journ. Roy. Geol. Soc. Ireland, n. s. vol. iii. p. 44, woodc.

Type. Nearly complete fish; British Museum.

The type species, attaining a length of at least 0·35. Trunk narrow and elongated, more than four times as long as the head with the opercular apparatus; tail produced and acutely pointed. Marginal teeth high and conical. Scales very thin, marked with delicate, granulated, radiating striæ.

Form. & Loc. Upper Old Red Sandstone: Dura Den, Fifeshire.

Fig. 39.



Phaneropleuron andersoni, Huxl.—Restored outline, by R. H. Traquair.

26120. A slab of yellow sandstone with remains of several individuals of *Holoptychius flemingi* and *Phaneropleuron andersoni,* including the type specimen of the latter, described and figured in Anderson's 'Dura Den,' pl. vi. fig. 2, and in the Mem. Geol. Surv. dec. x. pl. iii. fig. 1. One fish exhibits the conical marginal teeth, another apparently

the edge of a palatine dental plate, and another (as already noted by Huxley and Traquair) distinct jugular plates between the mandibular rami. *Purchased*, 1851.

26117 a. Large imperfect fish, figured by Huxley, Mem. Geol. Surv. dec. xiii. pl. iii. fig. 5. *Purchased*, 1851.

26117. Slab with imperfect remains of two individuals. Of one specimen the caudal region is figured by Huxley, Mem. Geol. Survey, dec. xiii. pl. iii. fig. 3; of the other specimen the pelvic fin is noticed, *ibid.* p. 48. *Purchased*, 1851.

24839. Imperfect large fish, showing axial skeleton. *Purchased*, 1850.

P. 704, P. 2076. Fragment of abdominal region of a large fish, and a slab with remains of three individuals, associated with *Holoptychius flemingi*. *Egerton Coll.*

Phaneropleuron curtum, Whiteaves.

1880. *Phaneropleuron curtum*, J. F. Whiteaves, Canadian Nat. n. s. vol. x. p. 29.
1887. *Phaneropleuron curtum*, J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. iv. sect. iv. p. 108, pl. x. fig. 2.
1889. *Phaneropleuron curtum*, J. F. Whiteaves, *ibid.* vol. vi. sect. iv p. 91, pl. v. fig. 3, pl. x. fig. 1.
1890. *Phaneropleuron curtum*, O. Jaekel, Sitzungsb. Ges. naturf. Freunde, p. 2, woodcut of upper dental plate.

Type. Nearly complete fish; Geological Survey of Canada. Ottawa.

Trunk scarcely more than twice as long as deep, less than four times as long as the head with the opercular apparatus; tail acutely pointed. Scales thicker than in the type species.

Form. & Loc. Upper Devonian: Scaumenac Bay, P.Q., Canada.

P. 5485–6. Imperfect fish, 0·215 in length, preserved in counterpart. *Purchased*, 1888.

P. 5487. Imperfect fish, 0·2 in length, displaying some of the head-bones and impressions of teeth, but wanting the paired fins. *Purchased*, 1888.

P. 5488. Trunk of a very small individual. *Purchased*, 1888.

The specimen mentioned below is not generically determinable, but may be referred to *Phaneropleuron* with much probability of correctness.

P. 198. Impression of small dental plate with five coarsely tuberculated, radiating ridges; Upper Old Red Sandstone, Farlow, Shropshire. *Weaver-Jones Coll.*

Genus **URONEMUS,** Agassiz.

[Poiss. Foss. vol. ii. pt. ii. 1844, p. 178.]

Syn. *Ganopristodus,* Geol. Mag. [2] vol. viii. 1881, p. 37.

Body somewhat laterally compressed, covered with very thin scales of moderate size. Notochord persistent. Marginal teeth laterally compressed; dental plates with series of well-separated, conical tubercles. Paired fins acutely lobate; dorsal fin single, arising in advance of the pelvic pair, continuous with the caudal; no separate anal fin.

Uronemus lobatus, Traquair.

1844. *Uronemus lobatus,* L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 178 (undefined).

1871. *Phaneropleuron elegans,* R. H. Traquair, Geol. Mag. vol. viii. p. 534. [Name subsequently withdrawn.]

1873. *Uronemus lobatus,* R. H. Traquair, Journ. Roy. Geol. Soc. Ireland, n. s. vol. iii. p. 41, pl. v.

Type. Imperfect fish; British Museum.

The type species, of small size, attaining a maximum length of about 0·2. Trunk narrow and elongated, at least five times as long as the head with the opercular apparatus; tail produced and acutely pointed. Marginal teeth in the form of low, laterally compressed, smooth-edged cones, confluent at their bases and brilliantly ganoid. Dorsal fin arising a very short distance behind the head. Scales very thin, marked with faint longitudinal or radiating striæ.

Form. & Loc. Calciferous Sandstones: Burdiehouse, near Edinburgh.

P. 2273. Caudal region and posterior portion of the abdominal region, being the type specimen noticed by Traquair, 1873. *Egerton Coll.*

P. 3276. Imperfect fish, described by Traquair, *ibid.* p. 47. *Enniskillen Coll.*

Uronemus splendens, Traquair.

[Plate IV. fig. 5.]

1881. *Ganopristodus splendens,* R. H. Traquair, Geol. Mag. [2] vol. viii. p. 37.
1882. *Ganopristodus splendens,* R. H. Traquair, *ibid.* vol. ix. p. 543.
1890. *Uronemus splendens,* R. H. Traquair, *ibid.* [3] vol. vii. p. 252.

Type. Jaws; collection of Dr. R. H. Traquair.

A species of somewhat larger size than the type; head and opercular apparatus occupying at least one quarter of the total length. Marginal teeth sometimes in part serrated, otherwise as in the type species. Scales oval, sometimes truncated, dull and smooth.

This is the type species of the so-called *Ganopristodus.*

Form. & Loc. Middle Carboniferous Limestone (Blackband Ironstone): Borough Lee, near Edinburgh.

P. 5986. Fragment of mandible with teeth, partly shown, of the natural size, in Pl. IV. fig. 5. *Purchased,* 1889.

Family CTENODONTIDÆ.

Cranial roof-bones numerous; no distinctly differentiated maxilla or premaxilla, and no marginal series of teeth above or below; jugular plates absent. Caudal fin diphycercal. Scales more or less cycloid.

Synopsis of Genera.

One median occipital plate; dental plates with numerous ridges	*Ctenodus* (p. 250).
Two median occipital plates; dental plates with fewer ridges	*Sagenodus* (p. 255).

Genus **CTENODUS,** Agassiz.

[Poiss. Foss. vol. iii. 1838, p. 137.]

Syn. (?) *Campylopleuron,* T. H. Huxley & E. P. Wright, Trans. Roy. Irish Acad. vol. xxiv. 1867, p. 353.

Body depressed, covered with large thin scales, almost quadrate in shape, but having the angles well rounded; both scales and external bones destitute of a ganoine-layer. A single median occipital plate, with a pair of plates immediately adjoining in front. Dental plates, above and below, triangular, irregularly ovate, or

elliptical in form, with numerous strong, outwardly directed ridges, tuberculated or crenulated. Dorsal and anal fins continuous with the caudal.

The remains of this genus and of the closely allied *Sagenodus* (p. 255) are usually very fragmentary, and the paired fins still remain unknown. The so-called *Campylopleuron* shows the form of the tail; but the only tolerably complete individuals hitherto discovered [1] are too imperfectly preserved for satisfactory discussion. A general review of the principal skeletal features already discovered is given by W. J. Barkas [2], Miall [3], and Fritsch [4]. Cranial roof-bones are also discussed and figured by Hancock and Atthey [5] and T. P. Barkas [6]; the palate is described by Miall [7], Hancock and Atthey [8], and T. P. Barkas [9]; the mandible by Atthey [10]; and the teeth especially by Hancock and Atthey [11] and W. J. Barkas [12]. The scales are first described and figured by Hancock and Atthey [13].

Ctenodus cristatus, Agassiz.

[Plate IV. fig. 1.]

1826. "Palate," J. De C. Sowerby, Zool. Journ. vol. ii. p. 23, pl. ii. fig. 2.

1838. *Ctenodus cristatus*, L. Agassiz, Poiss. Foss. vol. iii. p. 137, pl. xix. fig. 16.

1868. *Ctenodus cristatus*, T. Atthey, Ann. Mag. Nat. Hist. [4] vol. i. p. 83.

1868. *Ctenodus tuberculatus*, T. Atthey, *ibid.* p. 83. [Lower dental plates; Newcastle-on-Tyne Museum.]

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[1] Hancock & Atthey, Nat. Hist. Trans. Northumb. & Durham, vol. iii. p. 55; A. Fritsch, Fauna der Gaskohle, &c., Böhmens, vol. ii. p. 93, pl. lxxx. *b*.

[2] Proc. Roy. Soc. N. S. Wales, vol. x. (1877), pp. 99–123, and *ibid.* vol. xi. (1878), pp. 51–64.

[3] L. C. Miall, "On some Bones of *Ctenodus*," Proc. Yorksh. Geol. & Polyt. Soc. n. s. vol. vii. 1880, pp. 289–299, with figs.

[4] A. Fritsch, Fauna der Gaskohle, &c., Böhmens, vol. ii. pt. 3 (1888).

[5] Nat. Hist. Trans. Northumb. & Durham, vol. iv. p. 401.

[6] Coal Meas. Palæont. 1873, p. 113, figs. 244–246.

[7] Quart. Journ. Geol. Soc. vol. xxx. (1874), p. 772, pl. xlvii.

[8] Nat. Hist. Trans. Northumb. & Durham, vol. iv. p. 399, pl. xiv.

[9] Coal Meas. Palæont. p. 114, fig. 247.

[10] Nat. Hist. Trans. Northumb. & Durham, vol. v. p. 227, pl. v. figs. 1, 2.

[11] *Ibid.* vol. iii. p. 61 (dental plate).

[12] Proc. Roy. Soc. N. S. Wales, vol. x. (1877), pp. 99–109, with figs. (palatine dental plates); *ibid.* p. 115 (vomerine teeth). See also T. Atthey, Nat. Hist. Trans. Northumb. & Durham, vol. v. (1875), p. 228, pl. v. fig. 4 (vomerine teeth).

[13] Nat. Hist. Trans. Northumb. & Durham, vol. iii. p. 55; and *loc. cit.* vol. iv. p. 398, pl. xiii. fig. 3, p. 417, pl. xvi.

1869. *Ctenodus tuberculatus*, T. P. Barkas & H. Woodward, Geol. Mag. vol. vi. p. 317, pl. ix.
1869. *Ctenodus ovatus*, T. P. Barkas, Scientific Opinion, vol. ii. p. 557. [Upper dental plate; collection of T. P. Barkas, Esq.]
1870. *Ctenodus cristatus*, Hancock & Atthey, Nat. Hist. Trans. Northumb. & Durham, vol. iii. pp. 61, 92.
1870. *Ctenodus tuberculatus*, Hancock & Atthey, *ibid.* p. 61.
1872. *Ctenodus tuberculatus*, Hancock & Atthey, *ibid.* vol. iv. pl. xiv.
1873. *Ctenodus tuberculatus*, T. P. Barkas, Coal Meas. Palæont. p. 28, figs. 83, 84, 92.
1873. *Ctenodus ovatus*, T. P. Barkas, *ibid.* p. 28, fig. 89.
1873. *Ctenodus concavus*, T. P. Barkas, *ibid.* p. 28, fig. 88. [Abraded upper dental plate; collection of T. P. Barkas, Esq.].
1874. *Ctenodus cristatus*, L. C. Miall, Quart. Journ. Geol. Soc. vol. xxx. p. 772, pl. xlvii.
1875. *Ctenodus cristatus*, L. C. Miall, Ann. Mag. Nat. Hist. [4] vol. xv. p. 436.
1875. *Ctenodus cristatus*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 244, figs. 1, 2.
1875. *Ctenodus tuberculatus*, J. Ward, *ibid.* p. 246.
1877. *Ctenodus cristatus*, W. J. Barkas, Proc. Roy. Soc. N. S. Wales, vol. x. p. 102.
1877 *Ctenodus tuberculatus*, W. J. Barkas, *ibid.* p. 104, figs. 1, 10, 11, 23.
1877. *Ctenodus ovatus*, W. J. Barkas, *ibid.* p. 108, fig. 8.
1877. *Ctenodus concavus*, W. J. Barkas, *ibid.* p. 106, fig. 4.
1888. *Ctenodus cristatus*, A. Fritsch, Fauna der Gaskohle, vol. ii. p. 77, woodc. figs. 155, 156.
1890. *Ctenodus cristatus*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. pp. 154, 156, pl. iii. figs. 3, 4.
1890. *Ctenodus cristatus*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 51 (synonymy).

Type. Palatine dental plate; Leeds Museum.

The type species. Palatine dental plate broad-ovate or elliptical in form, attaining a length of about 0·08 and a maximum breadth of about 0·04; inner margin gibbous or gently rounded; coronal surface flat or slightly concave, with 12–14 acute, prominently tuberculated ridges, only slightly radiated; the tubercles laterally compressed. Mandibular dental plate relatively narrower and convex, similarly ridged.

Form. & Loc. Coal-Measures: England and South Scotland.

P. 5031. Imperfect skull exhibiting the upper surface, shown, of two-thirds the natural size, in Pl. IV. fig. 1; Great Row Coal, Clanway, North Staffordshire. The fragmentary remains and partial impression of a palatine dental plate

(*t.*) determine the anterior extremity of the specimen, and suggest its probable reference to *C. cristatus*. Nearly all the bones are considerably fractured on the external surface, and some are shown in little more than impressions; but the approximate outlines of most of the elements of the cranial shield appear to be distinguishable. Hindermost is a large median plate (O) elongated anteroposteriorly, and having the anterior margin produced mesially into a short triangular projection between the posterior extremities of the narrow pair of elements (I) immediately in front. The last-named bones are only in contact in the middle line of the skull for about half their extent in advance of the process of the hinder mesial element, being soon separated by another, though comparatively small and narrow, azygous bone (O); and this likewise extends between the hinder ends of a second larger pair (I), which would be originally in direct contact with the anterior ends of the first pair. This median series of bones is immediately flanked by four pairs of large broad bones, of which the first (II) and half of the second adjoin the hindermost element, while the third is in contact with both pairs of series I., and the fourth probably with the anterior inner pair alone. Still more externally there occurs another series of broad alternating bones on either side (III), of which only few fragments are preserved. On the whole, it will be noticed that there is a remarkable resemblance to the arrangement of the plates in the cranial shield of *Dipterus* (fig. 37), as already recognized by Hancock and Atthey[1]; the only striking difference being the apparent subdivision of some of the elements in the Devonian genus. Moreover, the median series of bones is arranged exactly as in *Acipenser* and *Polyodon*[2]. *Purchased*, 1885.

38857. Crushed remains of the head; Airdrie, Lanarkshire. The dental plates are much abraded and imperfectly exposed; a few of the posterior cranial roof-bones are distinguishable; and there are also portions of the palate, though broken almost beyond recognition. *Purchased*, 1864

45857. Operculum; Newsham. *Purchased*, 1874.

[1] Nat. Hist. Trans. Northumb. & Durham, vol. iv. p. 401.
[2] T. W. Bridge, Phil. Trans. 1878, p. 684, pl. lv.

36915. Much abraded palatine dental plate, resembling *C. ovatus*, Barkas; Dalkeith, near Edinburgh. *Purchased*, 1863.

21423. Similar dental plate, more imperfect; Carluke, Lanarkshire. *Purchased*, 1847.

21422. Slab with imperfect palatine dental plate, the partial impression of another, and fragments of bone; Carluke. *Purchased*, 1847.

P. 6264. Plaster cast of palatine dental plate described and figured in the Geol. Mag. vol. vi. p. 316, pl. ix. fig. 2; Low Main Seam, Newsham, near Newcastle-upon-Tyne.

P. 3382–3. Imperfect palatine dental plate, and a small example of the mandibular dental plate associated with *Sagenodus inæqualis*; Newsham. *Enniskillen Coll.*

41121. Mandibular dental plate detached from matrix, somewhat crushed, and figured in the Geol. Mag. vol. vi. pl. ix. fig. 3 (*C. tuberculatus*); Carluke. *Bryson Coll.*

45854. Imperfect left mandibular dental plate, with bone; Newsham. *Purchased*, 1874.

P. 774. Similar but larger specimen; (?) Newsham. *Egerton Coll.*

P. 5165. Mandibular dental plate; Hanley, Staffordshire. *Purchased*, 1885.

P. 5164. Portion of a larger dental plate; Tunstall, Staffordshire. *Purchased*, 1885.

Ctenodus interruptus, Barkas.

1869. *Ctenodus interruptus*, T. P. Barkas, Scientific Opinion, vol. ii. p. 113.

1890. *Ctenodus interruptus*, A. S. Woodward, Ann. Rep. Yorksh. Phil. Soc. 1889, p. 37, pl. i. fig. 2.

1890. *Ctenodus interruptus*, R. H. Traquair, Geol. Mag. [3] vol. vii. p. 249.

Type. Mandibular dental plate; York Museum.

Dental plates closely resembling those of *C. cristatus*, very variable in characters, with 12–14 ridges. Denticles very prominent and well separated in the outer moiety of the ridges, each much compressed in the direction of the ridge to which it pertains.

Form. & Loc. Calciferous Sandstones: Fifeshire and Midlothian. Carboniferous Limestone: Fifeshire, Midlothian, and Ayrshire.

Not represented in the Collection.

Ctenodus murchisoni, Ward.

[Plate IV. fig. 4.]

1843. *Ctenodus alatus*, L. Agassiz, Poiss. Foss. vol. iii. p. 174 (name only).

1844. *Ctenodus murchisoni*, L. Agassiz, Poiss. Foss. vol. i. p. xxxv (name only).

1890. *Ctenodus murchisoni*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 156.

Type. Palatine dental plate; British Museum.

Palatine dental plate attaining a length of about 0·7 and a maximum breadth of 0·04, irregularly oval in shape; coronal surface more or less concave, with about twenty small, acute, coarsely tuberculated ridges, scarcely radiated.

Form. & Loc. Upper Coal-Measures (Spirorbis Limestone): Shropshire and Lancashire. Middle Coal-Measures (Bassey Mine Ironstone): Staffordshire.

P. 518. Type specimen labelled in Agassiz's handwriting, shown, of the natural size, in Pl. IV. fig. 4; Leebotwood. The dental plate is of the left side, and the margins towards the anterior extremity are much broken. *Egerton Coll.*

The following species has also been described:—

Ctenodus wagneri, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 172, pl. xxvii. fig. 30.—Cleveland Shale (Lower Carboniferous); Ohio. [Columbia College, New York.]

The following species seems to be founded upon an abraded dental plate of *Ctenodus*:—

Conchodus plicatus, J. W. Dawson, Acadian Geol. ed. 2 (1868), p. 209, fig. 53.—Coal-Measures; Nova Scotia. [Redpath Museum, Montreal.]

Genus **SAGENODUS,** Owen.

[Trans. Odontol. Soc. vol. v. 1867, p. 365.]

Syn. *Petalodopsis*, W. J. Barkas, Monthly Rev. Dental Surgery, vol. ii. 1874, p. 538.

Ptyonodus, E. D. Cope, Proc. Amer. Phil. Soc. vol. xvii. 1878, p. 192.

Megapleuron, A. Gaudry, Enchaînements du Monde Animal, Foss. Primaires, 1883, p. 239.

Hemictenodus, O. Jaekel, Sitzungsb. Ges. naturf. Freunde, 1890, p. 7 (in part).

Body depressed, covered with large thin scales, almost quadrate in shape, but having the angles well rounded; both scales and external bones destitute of a ganoine-layer. A large median occipital plate posteriorly, with a smaller median plate immediately adjoining the front margin of this element. Dental plates, above and below, triangular, irregularly ovate or elliptical in form, with few strong, outwardly directed ridges, more or less tuberculated or crenulated; vomerine teeth resembling a single ridge of a dental plate. Dorsal and anal fins continuous with the caudal.

The name *Sagenodus* was first applied by Owen to a horizontal microscopical section of a dental plate; while that of *Ptyonodus* was given by Cope to dental plates differing only from those of *Ceratodus* in the non-punctate character of the coronal surface. The vomerine tooth was originally termed *Petalodopsis* by Barkas, on the erroneous supposition that it pertained to an Elasmobranch allied to *Petalodus*; and a head with the abdominal region, mingled with Palæoniscid scales, formed the type of *Megapleuron*, Gaudry. On account of the limited extent to which the ridges of the dental plates are tuberculated in the adult, the type species was associated by Jaekel, evidently in error, with a Ceratodont species from the Muschelkalk, and re-named *Hemictenodus*; and, without any allusion to synonymy, R. H. Traquair recently[1] adopted the latter term, while pointing out the essential feature in the diagnosis, *i. e.* the disposition of the median occipital bones.

Sagenodus inæqualis, Owen.

[Plate IV. figs. 2, 3.]

1867. *Sagenodus inæqualis,* R. Owen, Trans. Odontol. Soc. vol. v. p. 365, pl. xii.
1868. *Ctenodus obliquus,* T. Atthey, Ann. Mag. Nat. Hist. [4] vol. i. p. 84. [Dental plate; Newcastle-upon-Tyne Museum.]
1868. *Ctenodus elegans,* T. Atthey, *ibid.* p. 86. [Ditto.]
1868. *Ctenodus imbricatus,* T. Atthey, *ibid.* p. 86. [Ditto.]
1868. *Ctenodus ellipticus,* T. Atthey, *ibid.* p. 87. [Ditto.]
1870. *Ctenodus obliquus, elegans, imbricatus,* and *ellipticus,* Hancock & Atthey, Nat. Hist. Trans. Northumb. & Durham, vol. iii. pp. 63–66.
1872. *Ctenodus obliquus, elegans,* and *imbricatus,* Hancock & Atthey, *ibid.* vol. iv. p. 407, pl. xiii. figs. 1–3.
1873. *Ctenodus obliquus,* T. P. Barkas, Coal Meas. Palæont. p. 28, figs. 85, 90.
1873. *Ctenodus elegans,* T. P. Barkas, *ibid.* p. 28, fig. 86.

[1] Geol. Mag. [3] vol. vii. (1890), p. 251.

1873. *Ctenodus monoceros*, T. P. Barkas, *ibid.* p. 28, fig. 87. [Dental plate; collection of T. P. Barkas, Esq.]
1873. *Ctenodus quadratus*, T. P. Barkas, 'English Mechanic,' vol. xviii. p. 68, woodc. 1, 2. [Ditto.]
1874-75. *Petalodopsis mirabilis*, W. J. Barkas, Monthly Rev. Dental Surgery, vol. ii. p. 538, figs. xxx.–xxxii., and *ibid.* vol. iii. p. 4, figs. xxxiii.–xxxv. [Vomerine tooth.]
1874. *Ceratodus barrandei*, A. Fritsch, Sitzungsb. k. böhm. Ges. Wiss. p. 193 (first determined as probably referable to *C. obliquus* by L. C. Miall, Palæont. Indica, [4] vol. i. pt. ii. 1878, p. 17). [Dental plates; Royal Bohemian Museum.]
1875. *Ctenodus obliquus*, T. Atthey, Ann. Mag. Nat. Hist. [4] vol. xv. p. 309, pl. xix. (reprinted in Nat. Hist. Trans. Northumb. & Durham, vol. v. 1877, p. 227, pl. v.).
1875. *Ctenodus obliquus, imbricatus*, and *ellipticus*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, pp. 246, 247.
1877. *Ctenodus obliquus, elegans, imbricatus, ellipticus, monoceros*, and *quadratus*, W. J. Barkas, Proc. Roy. Soc. N. S. Wales, vol. x. pp. 105–108, figs. 3, 5–7, 12, 13, 20, 21.
1877. "Vomerine teeth of *Ctenodus*," W. J. Barkas, *ibid.* p. 115, figs. 14–19.
1881. *Ctenodus obliquus*, L. C. Miall, Proc. Yorksh. Geol. & Polyt. Soc. vol. vii. p. 291, woodc. fig. 4.
1888. *Ctenodus obliquus*, A. Fritsch, Fauna der Gaskohle, vol. ii. p. 66, pls. lxxi.–lxxix., pl. lxxx. figs. 5–12, and woodcuts.
1890. *Ctenodus obliquus*, Woodward & Sherborn, Catal. Brit. Foss. Vertebrata, p. 52 (synonymy).
1890. *Ctenodus obliquus*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 155, pl. iii. fig. 5.
1890. *Ctenodus imbricatus*, J. Ward, *ibid.* p. 155.
1890. *Ctenodus ellipticus*, J. Ward, *ibid.* p. 155, pl. iii. fig. 6.
1890. *Hemictenodus obliquus*, O. Jaekel, Sitzungsb. Ges. naturf. Freunde, p. 7
1890. *Hemictenodus obliquus*, R. H. Traquair, Geol. Mag. [3] vol. vii. p. 251.

Type. Section of lower dental plate; British Museum.

The type species. Palatine dental plate elongated, attaining a length of about 0·055 and a maximum breadth of 0·025; outer margin often nearly straight, inner border regularly arched; coronal surface flat or concave, with six or seven (rarely more) large, acute, very prominent radiating ridges, coarsely crenulated at the abrupt outer margin, more finely crenulated or smooth towards the inner margin. Mandibular dental plate only differing from the palatine in its comparative narrowness.

By A. Fritsch (*op. cit.* 1888) the dental plates named *C. elegans* are regarded as referable to young individuals of this species; and

it appears to the present writer that the so-called *C. imbricatus*, *C. ellipticus*, &c., are founded upon variously abraded dental plates. The dental plates of the Bohemian Permian variety frequently exhibit one or two small posterior coronal ridges more than is usual in the typical form.

Form. & Loc. Coal-Measures: Northumberland, Yorkshire, and Staffordshire, England; Lanarkshire, Scotland. Lower Permian: Bohemia.

45852. Hinder portion of cranial roof described and figured by T. P. Barkas, Coal. Meas. Palæont. p. 113, fig. 244; Low Main Seam, Newsham, near Newcastle-upon-Tyne.
Purchased, 1874.

P. 3387. Imperfect bone resembling the hinder median occipital of the preceding specimen; Newsham. *Enniskillen Coll.*

47478. Similar bone; Lower Permian, Kounová, Bohemia.
Purchased, 1876.

41632, 43497 a. Two opercula; Newsham.
Presented by T. P. Barkas, Esq., 1869, 1872.

P. 3386–7. Two opercula; Newsham. *Enniskillen Coll.*

(i.) *Palatine dental plates.*

45853, 45856. Palato-pterygoid with dental plate of right side; also a much abraded dental plate; Coal-Measures (Low Main Seam), Newsham, near Newcastle-upon-Tyne.
Purchased, 1874.

41627, 48999. Two abraded examples; Newsham.
Presented by T. P. Barkas, Esq., 1869, 1876.

P. 768. Two examples, slightly abraded; Newsham.
Egerton Coll.

P. 771. Right and left palato-pterygoids with dental plates; (?) Newsham. *Egerton Coll.*

P. 3376, P. 3379, P. 3381. Left palato-pterygoid with dental plate; also four abraded dental plates; Newsham.
Enniskillen Coll.

P. 5235. Abraded left dental plate; Coal-Measures, Tividale.
Purchased, 1886.

39249–50. Two dental plates; Coal-Measures, Airdrie, Lanarkshire.
Purchased, 1865.

P. 3391. Left dental plate, with a cranial roof-bone; Lower Permian, Kounová, Bohemia. *Enniskillen Coll.*

47471. Left dental plate; Kounová. *Purchased*, 1876.

(ii.) *Mandibular dental plates.*

45855, 45865 a. Two specimens of the right splenial, with dental plate; Newsham. *Purchased and by exchange*, 1874.

43494, 49000, 49001. Three abraded examples; Newsham. *Presented by T. P. Barkas, Esq.*, 1872, 1876.

P. 769, P. 773. Four examples, two being extremely abraded; Newsham. *Egerton Coll.*

P. 772. Right splenial with dental plate; (?) Newsham. *Egerton Coll.*

P. 3377. Right and left splenials, with dental plates, of one individual; Newsham. *Enniskillen Coll.*

P. 3378, P. 3380. Three specimens, left side; Newsham. *Enniskillen Coll.*

44145. Imperfect left dental plate; Newsham. *Purchased*, 1873.

P. 5236. Left dental plate; Tividale. *Purchased*, 1886.

P. 4588. Imperfect right splenial and dental plate, with other remains; also left dental plate; Coal-Measures, Longton, Staffordshire. *Enniskillen Coll.*

21423. Left dental plate, somewhat abraded and broken; Coal-Measures, Carluke, Lanarkshire. *Purchased*, 1847.

(iii.) *Dental plates of young individuals* (C. elegans).

P. 6246. Type specimen, being a thin horizontal section of a mandibular dental plate; Newsham. *Presented by Sir Richard Owen, K.C.B.*, 1890.

41733, 45865 b. Six examples; Newsham. *Purchased*, 1869, *and by exchange*, 1874.

P. 775. Right lower dental plate; Newsham. *Egerton Coll.*

P. 3381. Two examples, one shown, of twice the natural size, in Pl. IV. fig. 2; Newsham. *Enniskillen Coll.*

P. 3381 a. Two examples, one shown, of twice the natural size, in Pl. IV. fig. 3; Longton. *Enniskillen Coll.*

P. 5163. One example; Longton. *Purchased*, 1885.

The following specimens are specifically undetermined :—

41851. Impression of a palatine dental plate with six or seven radiating ridges arranged like those of *S. inæqualis*; Coal-Measures, Jarrow Colliery, Kilkenny.

Purchased, 1870.

41851 a. Much abraded dental plate showing five widely-spaced radiating coronal ridges; Kilkenny. *Purchased*, 1870.

Sagenodus quinquecostatus, Traquair.

1883. *Ctenodus obliquus*, var. *quinquecostatus*, R. H. Traquair, Geol. Mag. [2] vol. x. p. 543.

1890. *Hemictenodus quinquecostatus*, R. H. Traquair, *ibid.* [3] vol. vii. p. 251.

1890. *Sagenodus quinquecostatus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 387.

Type. Dental plate; collection of Dr. R. H. Traquair.

A smaller species than the type, the dental plates having not more than five complete ridges.

Imperfect skeletons of this fish are known, but not yet described. They are briefly noticed by Traquair, who remarks that the cranial roof-bones are shown to be arranged as in *S. inæqualis*.

Form & Loc. Middle Carboniferous Limestone (Blackband Ironstone): Borough Lee, near Edinburgh.

Not represented in the Collection.

The species mentioned below have also been founded upon dental plates, but the distinctness of some from those recorded above still remains doubtful.

Sagenodus (?) *angustulus*, R. H. Traquair, Geol. Mag. [2] vol. viii. p. 36 (*Ctenodus*).—Middle Carboniferous Limestone (Blackband Ironstone); Borough Lee, near Edinburgh. [R. H. Traquair Coll.]

Sagenodus applanatus, A. Fritsch, Fauna der Gaskohle, vol. ii. (1888), p. 85, pl. lxxii. figs. 1–3 (*Ctenodus*).—Lower Permian; Kounová, Bohemia. [Royal Bohemian Mus.]

Sagenodus carbonarius, H. Romanowsky, Bull. Soc. Imp. Nat. Moscou, 1864, pt. ii. p. 163, pl. iv. fig. 27 (*Ceratodus*).—Lower Carboniferous; Govt. of Toula, Russia.

Sagenodus caudatus, W. J. Barkas, Proc. Roy. Soc. N. S. Wales, vol. x. (1877), p. 109, fig. 9 (*Ctenodus*).—Coal-Measures; Northumberland. [W. J. Barkas Coll.]

Sagenodus corrugatus, T. Atthey, Ann. Mag. Nat. Hist. [4] vol. i. (1868), p. 84 (*Ctenodus*); Hancock & Atthey, Nat. Hist. Trans. Northumb. & Durham, vol. iii. (1870), p. 62 (*Ctenodus*); W. J. Barkas, Proc. Roy. Soc. N. S. Wales, vol. x. (1877), p. 106 (*Ctenodus*).—Coal-Measures; Northumberland. [Newcastle-upon-Tyne Mus.]

Sagenodus dialophus, E. D. Cope, Proc. Amer. Phil. Soc. vol. xvii. (1878), p. 528 (*Ctenodus*).—Permian; Texas. [E. D. Cope Collection, Philadelphia.]

Sagenodus fossatus, E. D. Cope, Proc. Amer. Phil. Soc. vol. xvii. (1878), p. 53 (*Ctenodus*).—Permian; East Illinois.

Sagenodus gurleyanus, E. D. Cope, *ibid.* p. 54 (*Ctenodus*).—Permian; East Illinois.

Sagenodus heterolophus, E. D. Cope, Proc. Acad. Nat. Sci. Philad. 1883, p. 109 (*Ctenodus*).—Permian; East Illinois.

Sagenodus obtusus, W. J. Barkas (*ex* T. P. Barkas), Proc. Roy. Soc. N. S. Wales, vol. x. (1877), p. 108 (*Ctenodus*).—Coal-Measures; Northumberland. [T. P. Barkas Coll.]

Sagenodus octodorsalis, T. P. Barkas, Scientific Opinion, vol. ii. (1869), p. 480 (*Ctenodus*); W. J. Barkas, Proc. Roy. Soc. N. S. Wales, vol. x. (1877), p. 106 (*Ctenodus*).—Coal-Measures; Northumberland. [T. P. Barkas Coll.]

Sagenodus paucicristatus, E. D. Cope, Proc. Amer. Phil. Soc. vol. xvii. (1878), p. 192 (*Ptyonodus*): *Ceratodus paucicristatus*, E. D. Cope, *ibid.* p. 53.—Permian; East Illinois.

Sagenodus periprion, E. D. Cope, Proc. Amer. Phil. Soc. vol. xvii. (1878), p. 527 (*Ctenodus*).—Permian; Texas.

Sagenodus porrectus, E. D. Cope, *ibid.* p. 527 (*Ctenodus*).—Permian; Texas. [E. D. Cope Collection, Philadelphia.]

Sagenodus pusillus, E. D. Cope, Proc. Amer. Phil. Soc. vol. xvii. (1878), p. 191 (*Ctenodus*).—Permian; Vermilion Co., Illinois.

Sagenodus reticulatus, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 60 (*Ctenodus*).—Coal-Measures; Linton, Ohio.

Sagenodus serratus, J. S. Newberry, *ibid.* p. 59, pl. lviii. figs. 15, 16 (*Ctenodus*), and Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 226, pl. xxxvii. fig. 31 (*Ctenodus*).—Coal-Measures; Linton, Ohio.

Sagenodus vabasensis, E. D. Cope, Proc. Acad. Nat. Sci. Philad. 1883, p. 110 (*Ctenodus*), and Trans. Amer. Phil. Soc. vol. xvi. (1886), p. 288 (*Ctenodus*).—Permian; East Illinois.

Sagenodus vinslovi, E. D. Cope, Proc. Amer. Phil. Soc. vol. xvii. (1878), p. 192 (*Ptyonodus*): *Ceratodus vinslovii*, E. D. Cope, Proc. Acad. Nat. Sci. Philad. 1875, p. 410.—Permian; East Illinois. [The type species of *Ptyonodus*.]

An imperfect specimen of *Sagenodus*, wanting the paired fins, from the Lower Permian of Bohemia, is named *Ctenodus tardus*, A. Fritsch., Fauna der Gaskohle, vol. ii. (1889), p. 93, pl. lxxx *b*. [Royal Bohemian Museum.]

Another head and abdominal region is named thus:—

Megapleuron rochei, A. Gaudry, Enchaînements du Monde Animal, Foss. Primaires (1883), p. 239, woodc. fig. 246[1].—Permian; Igornay, Saône-et-Loire. [Museum of Natural History, Paris.]

A portion of the cranium of a species of *Sagenodus*, from the Coal-Measures of Linton, Ohio, is also named *Ctenodus ohioensis*, E. D. Cope, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 410, pl. xlv. fig. 2 (erroneously assigned to an Amphibian, *Leptophractus obsoletus*, E. D. Cope, Proc. Acad. Nat. Sci. Philad. 1873, p. 341, and afterwards referred to *Ctenodus*, E. D. Cope, *ibid.* 1874, p. 91); J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol, Surv. no. xvi. 1889), p. 226, woodc. fig. 3. With this may probably be correlated the teeth described as *Ctenodus serratus*, or perhaps *C. reticulatus*.

The scales described as follows are also probably referable to *Sagenodus*:—

Ctenodus trachylepis, A. Fritsch, Fauna der Gaskohle, vol. ii. (1888), p. 85, pl. lxxx. figs. 1–4.—Lower Permian; Nyřan, Bohemia. [Royal Bohemian Museum.]

Rhizodus quadratus, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 343, pl. xxxix. fig. 8.—Coal-Measures; Linton, Ohio. [Columbia College, New York.]

Rhizodus reticulatus, Newberry & Worthen, Pal. Illinois, vol. iv. (1870), p. 349, pl. iii. figs. 9, 13, 14.—Coal-Measures; Illinois.

An undetermined tooth from the Burdiehouse Limestone, either of this genus or *Ctenodus*, is named *Ctenodus robertsoni*, L. Agassiz, Poiss. Foss. vol. iii. (1843), p. 174.

[1] As remarked by A. Fritsch (Fauna der Gaskohle, vol. ii. 1888, p. 65) the small rhombic scales assigned to this supposed distinct genus are those of a Palæoniscid fish mingled with the skeleton.

SKELETON OF *Ctenodus* AND *Sagenodus*.

The portions of skeleton mentioned below do not at present admit of generic and specific determination.

P. 3389. Bone of the form named squamosal by Miall (Proc. Yorksh. Geol. & Polyt. Soc. n.s. vol. vii. p. 293, woodc. fig. 6); Low Main Seam, Newsham, near Newcastle-upon-Tyne. *Enniskillen Coll.*

43497. Two imperfect parasphenoid bones; Newsham. *Presented by T. P. Barkas, Esq.*, 1872.

P. 778. Parasphenoid; (?) Newsham. *Egerton Coll.*

P. 3385. Two parasphenoids; Newsham. *Enniskillen Coll.*

P. 6265. Angular bone of mandible[1]; Newsham. *Enniskillen Coll.*

21421 a. Two imperfect ribs, one exhibiting two nodosities as if twice broken during life; Carluke, Lanarkshire. *Purchased*, 1847.

P. 3384. Three ribs; Newsham. *Enniskillen Coll.*

P. 4576. Three blocks of coal-shale with remains of the axial skeleton of the trunk (*Campylopleuron*, Huxley), very friable; Coal-Measures, Castlecomer, Kilkenny, Ireland. One specimen exhibits appearances very suggestive of a diphycercal tail. *Enniskillen Coll.*

P. 890. A few associated ribs of a small individual of "*Campylopleuron*"; Castlecomer. *Egerton Coll.*

37958. Caudal region described as *Uronemus magnus*, R. H. Traquair, Geol. Mag. [2] vol. i. (1874), p. 554; Coal-Measures (Blackband Ironstone), Airdrie, Lanarkshire. The specimen is referred to the Ctenodontidæ by the same author, *ibid.* [3] vol. vii. (1890), p. 252. *Purchased*, 1863.

P. 780. Bone identified as coracoid by Miall (*loc. cit.* p. 297, fig. 11) and Fritsch (*op. cit.* p. 82, pl. lxxii. figs. 11, 12, pl. lxxvii. figs. 3, 14, 15); (?) Newsham. *Egerton Coll.*

P. 3388 Similar bone; Newsham. *Enniskillen Coll.*

46953. Scale; Oldbury, Worcestershire. *Purchased*, 1876.

[1] This element of the mandible was originally identified as the articular by Atthey (Nat. Hist. Trans. Northumb. & Durham, vol. v. p. 227, pl. v. figs. 1, 2), and shown to be angular by Miall (Proc. Yorksh. Geol. & Polyt. Soc. n. s. vol. vii. p. 294, fig. 8).

Family LEPIDOSIRENIDÆ.

Cranial roof-bones few; no distinctly differentiated maxilla or premaxilla, and no marginal series of teeth above or below; jugular plates absent. Caudal fin diphycercal. Scales cycloid.

Genus **CERATODUS,** Agassiz.

[Poiss. Foss. vol. iii. 1838, p. 129.]

Syn. *Hemictenodus,* O. Jaekel, Sitzungsb. Ges. naturf. Freunde, 1890, p. 7 (in part).

Body elongate, laterally compressed, covered with very large thin scales, superficially calcified; head small and depressed, snout acute. Notochord persistent. Dental plates above and below triangular or irregularly ovoid in shape, with outwardly radiating, smooth ridges

Fig. 40.

Ceratodus forsteri, Krefft.—Open mouth, showing dentition: *n*, narial openings; x, vomerine teeth xx, palatine dental plates; xxx, mandibular dental plates.

forming a series of very large processes at the external margin, which are sometimes feebly denticulated. Paired fins acutely lobate; dorsal fin arising about the middle of the back, both this and the anal fin being continuous with the caudal.

This definition is given on the assumption that the early Mesozoic teeth originally named by Agassiz pertain to a fish identical in

generic characters with the so-called *Ceratodus forsteri*[1] of the Queensland rivers. The extinct species may constitute a distinct type—*e. g.*, perhaps that already named *Gosfordia* (p. 275); and, in that case, the definition just stated will only apply to the recent fish, for which a new generic name will be required.

Fig. 41.

Ceratodus forsteri, Krefft.—Recent, Queensland Rivers.

Ceratodus latissimus, Agassiz.

1811. "*Trionyx*," J. Parkinson, Organic Remains, vol. iii. p. 269, pl. xviii. fig. 1.

1838. *Ceratodus latissimus*, L. Agassiz, Poiss. Foss. vol. iii. p. 131, pl. xx. figs. 8, 9.

1838. *Ceratodus curvus*, L. Agassiz, *ibid.* p. 131, pl. xx. fig. 10. [Dental plate; Bristol Museum.]

1838. *Ceratodus planus*, L. Agassiz, *ibid.* p. 132, pl. xx. figs. 6, 7. [Ditto.]

1838. *Ceratodus emarginatus*, L. Agassiz, *ibid.* p. 133, pl. xx. figs. 11–13. [Ditto.]

1838. *Ceratodus gibbus*, L. Agassiz, *ibid.* p. 133, pl. xx. figs. 14, 15. [Ditto.]

1838. *Ceratodus dædaleus*, L. Agassiz, *ibid.* p. 133, pl. xx. fig. 16.

1838. *Ceratodus altus*, L. Agassiz, *ibid.* p. 134, pl. xviii. figs. 1, 2, pl. xx. figs. 2–5.

1844. *Ceratodus trapezoides*, T. Plieninger, in Meyer & Plieninger's Pal. Württembergs, p. 87, pl. xii. fig. 50. [Stuttgart Museum.]

1850. *Ceratodus anglicus*, E. Beyrich, Zeitschr. deutsch. geol. Gesell. vol. ii. p. 159.

1858. *Ceratodus cloacinus*, F. A. Quenstedt, Der Jura, p. 34, pl. ii. fig. 28. [Dental plate; Tübingen University Museum.]

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[1] G. Krefft, "Description of a gigantic Amphibian allied to the genus *Lepidosiren*, from the Wide-Bay District, Queensland," Proc. Zool. Soc. 1870, p. 221, woodc. 1–3. A. Günther, "Description of *Ceratodus*, a genus of Ganoid Fishes, recently discovered in Rivers of Queensland, Australia," Phil. Trans. 1871, pp. 511–571, pls. xxx.–xlii. See also T. H. Huxley, Proc. Zool. Soc. 1876, pp. 24–59, with figs.

1878. *Ceratodus polymorphus*, L. C. Miall, Monogr. Siren. and Crossopt. Ganoids (Mon. Palæontogr. Soc.), p. 28, pl. ii. figs. 1–13, pl. iii. figs. 1, 2, 5, pl. iv. figs. 1-11, pl. v. figs. 1, 5.

1889. *Ceratodus latissimus*, A. S. Woodward, Trans. Leicester Lit. & Phil. Soc. n. s. pt. xi. p. 21.

Type. Lower dental plate ; Bristol Museum.

The type species. Dental plates robust, attaining a maximum length of about 0·085, usually much longer than broad, varying in shape from triangular to oval and oblong ; inner margin more or less sharply angulated ; coronal surface generally sinuous, sometimes flat, and deeply pitted. Denticles four in the mandibular dental plates, four and a rudiment or five in the palatine, the ridges being low and rounded, ill-defined, and not reaching the internal margin.

A long series of figures of the dental plates of this species is given by Miall, *op. cit.*

Form. & Loc. Rhætic: Gloucestershire and Leicestershire, England ; Würtemberg.

All the following dental plates were obtained from the Rhætic Section of Aust Cliff, near Bristol. The mandibular are distinguished from the palatine not merely by the absence of a fifth denticle, but also frequently by the prismatic form of the most anterior denticle, this being adapted to two grinding surfaces.

(i.) *Upper dental plates.*

P. 4438 a. Plaster casts of four specimens and two associated dental plates, figured by Miall, *op. cit.* pl. iv. figs. 1, 3, 4, 7, 8; originals in the Higgins Collection, Bristol Museum. *Enniskillen Coll.*

P. 4438. Plaster casts of sixteen specimens; originals in the Higgins Collection. *Enniskillen Coll.*

23153. Small imperfect dental plate. *Purchased*, 1849.

28280. Seven examples. *Purchased*, 1853.

28495, 29035. Three specimens, one having an only gently sinuous external margin. *Purchased*, 1853–54.

35002–4, 35007, 36387. Five specimens. *Purchased*, 1860, 1862.

41287. Narrow dental plate. *Purchased*, 1869.

42721. Very broad triangular dental plate. *Presented by H. N. Moseley, Esq.*, 1871.

P. 3393. Six specimens. *Enniskillen Coll.*

P. 5012. Dental plate in matrix.
Presented by John Edward Lee, Esq., 1885.

(ii.) *Lower dental plates.*

P. 4438 b. Plaster casts of four specimens, figured by Miall, *op. cit.* pl. ii. figs. 1, 6, 8, pl. iii. fig. 1; originals in the Higgins Collection. *Enniskillen Coll.*

P. 4438 c. Plaster casts of seventeen specimens; originals in the Higgins Collection. *Enniskillen Coll.*

23153 a, 24840. Two specimens, the first doubtfully of the lower jaw. *Purchased*, 1849–50.

28280 a, 28495 a, 28541, 28858. Five specimens.
Purchased, 1853–54.

34984–5. Two specimens, one much abraded. *Purchased*, 1860.

35005, 35008, 36387 a. Five specimens. *Purchased*, 1860, 1862.

41287 a. Two specimens. *Purchased*, 1869.

42721 a. Three dental plates.
Presented by H. N. Moseley, Esq., 1871.

P. 344. Dental plate in matrix, with spine of *Nemacanthus*.
Purchased, 1881.

P. 761. Sixteen dental plates and fragments, mostly mandibular.
Egerton Coll.

P. 3394. Eight specimens. *Enniskillen Coll.*

Ceratodus parvus, Agassiz.

1838. *Ceratodus parvus*, L. Agassiz, Poiss. Foss. vol. iii. p. 132, pl. xx. fig. 1.
(?) 1838. *Ceratodus obtusus*, L. Agassiz, *ibid.* p. 134, pl. xix. fig. 20. [Dental plate; British Museum.]
1878. *Ceratodus parvus*, L. C. Miall, Monogr. Siren. & Crossopt. Ganoids (Mon. Palæontogr. Soc.), p. 29, pl. v. figs. 3, 4, 6–10.
(?) 1878. [*Ceratodus obtusus*], L. C. Miall, *ibid.* p. 30.

Type. Imperfect dental plate; Bristol Museum.

A species evidently closely allied to *C. latissimus*, but only attaining about half the size of the latter, and with dental plates more constant in form. Dental plates triangular, the inner margin being sharply angulated opposite, or nearly opposite, the second denticle. Denticles usually four in the mandibular dental plates, five in the

palatine, laterally compressed; ridges often prominent, sometimes extending almost to the inner angulation.

The possibility of this dental plate being the immature form of *C. latissimus* is discussed by Miall, *op. cit.*

Form. & Loc. Rhætic: Gloucestershire[1].

All the following dental plates were obtained from Aust Cliff, near Bristol.

(i.) *Upper dental plates.*

P. 3392. Type specimen of *C. obtusus*, Agassiz, apparently owing the obtuseness of the denticles to wearing during life.
Enniskillen Coll.

11211. Specimen figured by Miall, *op. cit.* pl. v. fig. 6.
Mantell Coll.

P. 4438 d. Plaster cast of dental plate figured by Miall, *op. cit.* pl. v. fig. 4. *Enniskillen Coll.*

P. 4438 e. Plaster casts of four dental plates. *Enniskillen Coll.*

(ii.) *Lower dental plates.*

44834. Specimen with five denticles attached to bone and assigned to the mandible by Miall, *op. cit.* pl. v. fig. 3.
Presented by Benjamin Bright, Esq., 1873.

28858 a. Specimen figured by Miall, *op. cit.* pl. v. fig. 7.
Purchased, 1854.

P. 4438 f. Plaster cast of fragment figured by Miall, *op. cit.* pl. v. fig. 8; original in the Higgins Collection, Bristol Museum.
Enniskillen Coll.

As remarked by Miall (*op. cit.* p. 31), the so-called *C. disauris*, Agassiz (*tom. cit.* p. 135, pl. xix. fig. 19, "*C. bicornis*"), is obviously an abnormal dental plate. The type specimen (**P. 493**, *Egerton Coll.*) was obtained from the Rhætic Section of Aust Cliff, near Bristol, and is probably referable to *C. parvus*.

Ceratodus guentheri, Marsh.

1878. *Ceratodus güntheri*, O. C. Marsh. Amer. Journ. Sci. [3] vol. xv. p. 76, woodc.

Type. Upper dental plate; Yale College Museum.

[1] Dental plates from the Upper Keuper of Tübingen, Würtemberg, are also considered to pertain to this species by F. A. Quenstedt, Handb. Petrefakt. ed. 3, p. 298, pl. xxiv. figs. 4–8.

Dental plates robust, attaining a length of about 0·02, irregularly triangular; inner border obtusely angulated at a point near its middle. Denticles four in the mandibular dental plates, five in the palatine, the ridges rounded, separated by deep notches at the outer border, terminating abruptly and extending more than halfway to the inner angulation.

Form. & Loc. Upper Jurassic: Colorado.

Not represented in the Collection.

Ceratodus capensis, A. S. Woodward.

1889. *Ceratodus capensis*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. iv. p. 243, pl. xiv. fig. 4.

Type. Dental plate; British Museum.

Dental plates thin, attaining a length of not less than 0·023, triangular in shape; angulation of inner margin acute and placed near the posterior extremity. Denticles five or six, the ridges being acute, well separated by deep and wide notches and valleys, extending within a short space of the inner angulation, gradually sloping to a point at the outer border, and very faintly marked with coarse crenulations.

Form. & Loc. Upper Karoo Formation (Stormberg Beds): Orange Free State, South Africa.

P. 4807. Type specimen, wanting one or perhaps two anterior denticles; Smithfield. *By exchange*, 1884.

Ceratodus phillipsi, Agassiz.

1838. *Ceratodus philippsii*, L. Agassiz, Poiss. Foss. vol. iii. p. 135, pl. xix. fig. 17.

1877. *Ceratodus phillipsi*, A. Crane, Geol. Mag. [2] vol. iv. p. 211.

1890. *Ceratodus phillipsi*, A. S. Woodward, Proc. Geol. Assoc. vol. xi. p. 292, pl. iii. fig. 5.

Type. Dental plate; unknown.

Dental plates thin, attaining a length of about 0·02, almost triangular in shape; angulation of inner margin acute and placed near the posterior extremity. Denticles four or five (? or six), the ridges being sharply rounded, well separated by deep notches and valleys, extending nearly to the inner angulation and terminating abruptly at the outer border.

Form. & Loc. Bathonian: Oxfordshire (Stonesfield Slate) and Northamptonshire (Great Oolite).

Not represented in the Collection, unless the dental plate mentioned below be a much abraded example from the lower jaw:—

11164. Much abraded left lower dental plate, doubtfully ascribed to this species by L. C. Miall, Siren. & Crossopt. Ganoids (Mon. Palæontogr. Soc. 1878), p. 32, pl. v. fig. 13; one of a series of sixty fossils entered "from the Stonesfield Slate, Cornbrash, and Forest Marble." *Mantell Coll.*

Ceratodus kaupi, Agassiz.

1838. *Ceratodus kaupii*, L. Agassiz, Poiss. Foss. vol. iii. p. 131, pl. xviii. figs. 3, 4.

1844. *Ceratodus guilielmi*, T. Plieninger, in Meyer & Plieninger's Pal. Württembergs, p. 86, pl. x. figs. 7, 8, 13. [Dental plates; Stuttgart Museum.]

1844. *Ceratodus palmatus*, T. Plieninger, *ibid.* p. 87, pl. x. fig. 9. [Ditto.]

1844. *Ceratodus kurrii*, T. Plieninger, *ibid.* p. 87, pl. x. figs. 10, 11. [Ditto.]

1844. *Ceratodus weissmanni*, T. Plieninger, *ibid.* p. 87, pl. xi. fig. 10. [Ditto.]

1850. *Ceratodus kaupii*, E. Beyrich, Zeitschr. deutsch. geol. Ges. vol. ii. p. 160, pl. vi. figs. 1, 2.

1852. *Ceratodus kaupii*, F. A. Quenstedt, Handb. Petrefakt. p. 187, pl. xiv. fig. 12.

1862. *Ceratodus runcinatus*, C. Schlumberger (*errore*), Bull. Soc. géol. France, [2] vol. xix. p. 707, pl. xvii.

(?) 1878. *Ceratodus lævissimus*, L. C. Miall, Monogr. Siren. & Crossopt. Ganoids (Mon. Palæontogr. Soc.), p. 32, pl. v. fig. 2. [Dental plate; British Museum.]

1886. *Ceratodus kaupi*, K. A. von Zittel, Sitzungsb. k. bay. Akad. Wiss. math.-phys. Cl. p. 258, figs. 1–4.

Type. Upper dental plate; Stuttgart Museum.

Dental plates thin, attaining a maximum length of about 0·055, triangular in shape; angulation of inner margin acute and often mesially placed, the two moieties of this margin being usually somewhat arched; coronal surface gently sinuous or flat. Denticles four in the mandibular dental plates, five in the palatine, the ridges being low, sharply rounded, ending obtusely and separated by very deep notches at the outer margin, and extending at least halfway to the inner angulation.

Form. & Loc. Upper Muschelkalk: Thuringia. Lettenkohle: Würtemberg. (?) Upper Keuper: Worcestershire, England.

Except when otherwise stated, the following specimens were obtained from the Lettenkohle of Hoheneck, near Ludwigsburg, Würtemberg.

(i.) *Upper dental plates.*

21228. Twelve specimens, some imperfect. *Purchased*, 1847.

21530. Small dental plate in matrix. *Purchased*, 1847.

28452. Two specimens. *Purchased*, 1853.

38662. Twenty-two dental plates, some completely detached from the matrix. *Purchased*, 1864.

P. 764, P. 766. Three specimens. *Egerton Coll.*

P. 3396–7. Six specimens, one showing the inferior aspect. *Enniskillen Coll.*

P. 5017. Small dental plate in matrix. *Presented by John Edward Lee, Esq.*, 1885.

46956. Type specimen of *C. lævissimus*, much broken, probably of this species; Upper Keuper, Ripple, Worcestershire. *Purchased*, 1876.

(ii.) *Lower dental plates.*

21228 a. Two specimens. *Purchased*, 1847.

28451, 28454. Five specimens. *Purchased*, 1853.

38662 a. Twenty-six specimens, one being abnormal. *Purchased*, 1864.

40322 a. Large dental plate, showing broad prismatic first denticle. *Purchased*, 1867.

P. 763. Seven specimens. *Egerton Coll.*

P. 3399. One specimen. *Enniskillen Coll.*

As remarked by Quenstedt (*op. cit.*), the so-called *C. kurrii* is founded upon small dental plates too much abraded for specific determination. Some of the following specimens are of a similar character; but the majority exhibit four or five denticles, and they may probably all be regarded as immature dental plates of *C. kaupi*.

21228 b, 21530 a. Seven very fragmentary dental plates; Hoheneck. *Purchased*, 1847.

28454 a. Five abraded specimens; Hoheneck. *Purchased*, 1853.

38662 b. Twenty-five abraded specimens; Hoheneck. *Purchased*, 1864.

28454 b. Much abraded dental plate; Lettenkohle, Bibersfeld. *Purchased*, 1853.

Ceratodus runcinatus, Plieninger.

1844. *Ceratodus runcinatus*, T. Plieninger, in Meyer & Plieninger's Pal. Württembergs, p. 86, pl. xi. fig. 8.
1850. *Ceratodus serratus*, E. Beyrich, Zeitschr. deutsch. geol. Ges. vol. ii. p. 163, pl. vi. figs. 3, 4.
1852. *Ceratodus runcinatus*, F. A. Quenstedt, Handb. Petrefakt. p. 187.
1871. *Ceratodus runcinatus*, A. Günther, Phil. Trans. pl. xxxi. fig. 10, pl. xxxiii. figs. 4–6.
1890. *Hemictenodus intermedius*, O. Jaekel, Sitzungsb. Ges. naturf. Freunde, pp. 4, 6, woodcut. [Dental plate; Berlin Museum.]

Type. Lower dental plate; Stuttgart Museum.

Dental plates thick and robust, attaining a maximum length of about 0·065, triangular in shape; angulation of inner margin acute, placed close to the posterior extremity. Denticles five in the mandibular dental plates, five and a small or rudimentary sixth in the palatine, very prominent and acute, much laterally compressed, separated by deep notches at the outer margin, and continuous with ridges extending almost or quite to the inner angulation.

Form. & Loc. Lettenkohle: Würtemberg.

All the following specimens were obtained from Hoheneck, near Ludwigsburg:—

(i.) *Upper dental plates.*

28450. Specimen wanting first denticle. *Purchased*, 1853.

38661. Two dental plates attached to bone, and six isolated examples. *Purchased*, 1864.

40321. Broken specimen in matrix. *Purchased*, 1867.

P. 765. Fine dental plate in matrix. *Egerton Coll.*

(ii.) *Lower dental plates.*

21228 e. Fine specimen figured by Günther, *loc. cit.* pl. xxxi. fig. 10. *Purchased*, 1847.

21228 d. Dental plate of which microscopical sections are figured by Günther, *loc. cit.* pl. xxxii. figs. 4–6. *Purchased*, 1847.

21228 c. Four specimens. *Purchased*, 1847.

28450 a. Abraded specimen. *Purchased*, 1853.

38661 a. Small abraded specimen, and a large dental plate less abraded. *Purchased*, 1864.

42846. Broken specimen in matrix. *Van Breda Coll.*

P. 3395. Fine dental plate and a small abraded specimen. *Enniskillen Coll.*

28469. Very small dental plate, exhibiting only four ridges, perhaps pertaining to young of this species. *Purchased*, 1853.

Ceratodus hislopianus, Oldham.

1859. *Ceratodus hislopianus*, T. Oldham, Mem. Geol. Surv. India, vol. i. p. 300, pl. xiv. figs. 1–7, pl. xvi. fig. 1.
1878. *Ceratodus hislopianus*, L. C. Miall, Palæont. Indica, [4] vol. i. pt. ii. p. 16, pl. iv. fig. 5.

Type. Detached dental plates; Indian Museum, Calcutta.

Dental plates thick and robust, much resembling those of *C. runcinatus*, but having the denticles usually less compressed and never more than 4–5 in number.

Form. & Loc. Trias (Kota-Maleri Group): India.

P. 3400. Palatine and two imperfect mandibular dental plates; Maleri, near Nagpur. *Enniskillen Coll.*

P. 762. Imperfect mandibular dental plate. *Egerton Coll.*

Ceratodus hunterianus, Oldham.

1859. *Ceratodus hunterianus*, T. Oldham, Mem. Geol. Surv. India, vol. i. p. 303, pl. xv. figs. 1–6, pl. xvi. fig. 4.
1878. *Ceratodus hunterianus*, L. C. Miall, Palæont. Indica, [4] vol. i. pt. ii. p. 16, pl. iv. figs. 1–3, 6–8.

Type. Detached dental plates; Indian Museum, Calcutta.

Dental plates thick and robust, scarcely distinguishable from those of *C. hislopianus*, except by the greater size and prominence of the foremost denticle and the frequently less pronounced character of the coronal ridges.

Form. & Loc. Trias (Kota-Maleri Group): India.

P. 3401. Mandibular dental plate; Maleri, near Nagpur. *Enniskillen Coll.*

A large portion of the skull and mandible of a species of *Ceratodus* from the Upper Keuper of Pölzberg, near Lunz, Austria, is noticed by D. Stur, Verhandl. k.-k. Geol. Reichsanst. 1886, p. 381.

The caudal region of a species from the Lettenkohle of Bavaria, now in the University Museum, Würzburg, has been described under the name of *Cœlacanthus giganteus*, T. C. Winkler, Archiv.

Mus. Teyler, vol. v. (1880), p. 141, pl. ix. See K. A. von Zittel, Sitzungsb. k. bay. Akad., math.-phys. Cl. 1886, p. 259.

Dental plates, said to be identical with those of the recent *Ceratodus forsteri*[1], occur in the superficial Alluvial Deposits of Darling Downs, Queensland. One of these is noticed in 'Nature,' vol. ix (1874), p. 293, under the name of *C. palmeri*, Krefft. The following is a cast of the same :—

45868. Plaster cast of imperfect upper dental plate, having only three sharply compressed horns preserved; Alluvial Deposit, Darling Downs, Queensland.

Presented by Dr. A. Günther, 1872.

The following species have also been founded upon detached dental plates, but there are no examples in the Collection :—

Ceratodus arenaceus, F. A. Quenstedt, Handb. Petrefakt. 3rd edit. (1883), p. 296, pl. xxiv. fig. 3.—Upper Bunter; Süldorf, near Magdeburg. [Tübingen University Museum.]

Ceratodus concinnus, T. Plieninger, in Meyer & Plieninger's Pal. Württembergs (1844), p. 85, pl. xi. fig. 9.—Keuper; Stuttgart. [Stuttgart Museum.]

Ceratodus cornutus, F. A. Quenstedt, Handb. Petrefakt. 3rd. edit. (1883), p. 297, pl. xxiii. fig. 39.—Upper Muschelkalk; Wilhelmsglück. [Tübingen University Museum.]

Ceratodus favosus, E. D. Cope, Proc. Amer. Phil. Soc. 1884, p. 28. —Permian; Texas. [E. D. Cope Collection, Philadelphia.]

Ceratodus gypsatus, F. A. Quenstedt, Begleitw. geogn. Specialk Württ. Atlasbl. Hall (1880), p. 26; Handb. Petrefakt. 3rd edit. (1883), p. 297, pl. xxiv. fig. 2.— Keuper; Würtemberg. [Tübingen University Museum.]

Ceratodus margatus, F. A. Quenstedt, Begleitw. geogn. Specialk. Württ. Atlasbl. Hall (1880), p. 23; Handb. Petrefakt. 3rd edit. (1883), p. 297, pl. xxiv. fig. 1.—Keuper; Würtemberg. [Tübingen University Museum.]

Ceratodus serratus, L. Agassiz, Poiss. Foss. vol. iii. (1838), p. 135, pl. xix. fig. 18.—Keuper; Aargau, Switzerland. [Identified with *C. runcinatus* by E. Beyrich, Zeitschr. deutsch. geol. Ges. vol. ii. (1850), p. 163.]

Ceratodus silesiacus, F. A. Roemer, Geol. von Oberschlesien (1870), p. 184, pl. xv. figs. 6, 7.—Rhætic (Breccia); Lissau, Silesia. [University of Breslau.]

Ceratodus virapa, T. Oldham, Mem. Geol. Surv. India, vol. i.

[1] C. W. De Vis, Proc. Roy. Soc. Queensland, vol. i. (1884), p. 40.

(1859), p. 305, pl. xiv. figs. 8–12, pl. xvi. fig. 2; L. C. Miall, Palæont. Indica, [4] vol. i. pt. ii. (1878), p. 16, pl. iv. fig. 4: *Ceratodus oblongus*, T. Oldham, *tom. cit.* p. 307, pl. xv. figs. 7, 8.—Kota-Maleri Beds; Maleri, near Nagpur, India. [Indian Museum, Calcutta.]

Fragments of dental plates of *Ceratodus*, from the Rhætic Bone-bed of Würtemberg, are erroneously described by Plieninger (Meyer & Plieninger's Pal. Württembergs, p. 117, pl. x. figs. 14–16) under the name of *Psammodus porosus*.

The so-called *Ceratodus heteromorphus*, Agassiz (Poiss. Foss. vol. iii. 1838, p. 136, pl. xviii. figs. 32–34), is founded upon a cephalic spine of a Hybodont Selachian (*supra*, Part I. p. 306), a much abraded Ceratodont dental plate, and a very doubtful tooth from the Muschelkalk. This "species" must, therefore, be removed from the list, as remarked by E. Fraas, Württ. Jahresh. vol. xlv. (1889), p. 233.

Two fossils from the Upper Cretaceous Fort Union Beds of Montana, as yet not satisfactorily determined, are named *Ceratodus eruciferus* and *C. hieroglyphus*, E. D. Cope, Proc. Acad. Nat. Sci. Philad. 1876, pp. 259, 260.

Family position uncertain.

Genus **GOSFORDIA,** A. S. Woodward.

[Foss. Fishes Hawkesbury Series, Gosford (Mem. Geol. Surv. N. S. Wales, Palæont. no. iv. 1890), p. 4.]

Head very small; snout pointed; trunk elongate, though comparatively deep, laterally compressed. Median fin continuous; pelvic fins acutely lobate, biserially fringed. Scales very small, delicate, overlapping, marked by fine striæ.

Gosfordia truncata, A. S. Woodward.

1890. *Gosfordia truncata*, A. S. Woodward, *op. cit.* p. 5, pl. i., pl. ii. figs. 1, 2.

Type. Head and abdominal region; Geol. Surv. Museum, Sydney.

The type and only known species, attaining a length of about 0·6. Maximum depth of trunk contained somewhat more than three times in the total length.

Form. & Loc. Lower Hawkesbury Beds (Upper Triassic): Gosford, New South Wales.

Not represented in the Collection.

Genus **CONCHOPOMA**, Kner.

[Sitzungsb. math.-naturw. Cl. k. Akad. Wiss. vol. lvii. 1868, pt. i. p. 279.]

Head relatively large and opercular apparatus robust, the operculum convex and shaped like the valve of a bivalve shell; dental plates covered with irregularly arranged, stout, conical or rounded tubercles. Trunk elongate and laterally compressed; median fin continuous. Scales small, delicate, striated.

Conchopoma gadiforme, Kner.

1844. *Cœlacanthus munsteri*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 173 (undefined).

1868. *Conchopoma gadiforme*, R. Kner, Sitzungsb. math.-naturw. Cl. k. Akad. Wiss. vol. lvii. pt. i. p. 278, pls. i.–iv.

Type. Well-preserved fishes; Museums of Berlin and Strassburg.

The type and only known species, of small size. Length of head with opercular apparatus about equal to the maximum depth of the trunk, and contained about four times in the total length.

Form. & Loc. Lower Permian: Rhenish Prussia.

P. 507, P. 3336. Nodule with nearly complete fish, wanting the margins of the median fin and the paired fins, intended to be the type specimen of *Cœlacanthus muensteri*, Ag.; Lebach. *Eyerton & Enniskillen Colls.*

Order II. ARTHRODIRA.

Head with well-developed dermal or membrane bones; principal upper dentition on the elements of the pterygo-palatine arch. Dermal armour of abdominal region consisting of large plates, of which a dorso-lateral pair articulate by a movable ginglymoid joint with the occipital border of the cranial shield. Notochord persistent. Paired fins rudimentary or absent; pelvic basipterygia [so far as known] consisting of a pair of sigmoidal or club-shaped cartilages.

Only a single family, that of Coccosteidæ, can be referred to this order with certainty; but two other imperfectly known families (Asterosteidæ and Mylostomatidæ) may also be placed here with much probability of correctness.

Family COCCOSTEIDÆ.

Cranial shield consisting of few elements:—a median occipital, with two pairs of bones following immediately in front, this series being terminated by an anterior azygous element over the ethmoidal region; three lateral pairs of bones forming the sides of the shield. Narial openings small and anteriorly situated. Maxilla and premaxilla well developed, but toothless; dentition, when present, consisting of conical teeth fused with the oral margin of the mandible and with two inner pairs of bones in the upper jaw (presumably palatine and vomerine). Abdominal region with a dorsal and ventral armature, the large dorsal plate having a deep inner longitudinal keel, evidently for connection with the neural arches of the endoskeletal axis.

Synopsis of Genera.

I. Orbits forming notches in the cranial shield.
  A. No pineal foramen.
    Median bone over pineal region; no pectoral spine ..... *Coccosteus* (p. 278).
    Similar, but with pectoral spine .... *Brachydirus* (p. 294).
    No median bone over pineal region; no pectoral spine ..... *Phlyctænaspis* (p. 295).
  B. Pineal foramen present.
    Scutes ornamented with fused series of tubercles ..... *Chelyophorus* (p. 299).
    Scutes smooth or faintly rugose; teeth prominent ..... *Dinichthys* (p. 300).
    Scutes smooth or faintly rugose; no teeth in mandible ..... *Titanichthys* (p. 302).
II. Orbits completely enclosed in the cranial shield.
    Scutes finely and closely tuberculated; cranial shield much arched. *Macropetalichthys* (p. 303).
    Scutes finely and closely tuberculated; cranial shield nearly flat; antero-lateral processes of abdominal shield small ..... *Homosteus* (p. 304).
    Scutes coarsely and sparsely tuberculated; cranial shield nearly flat; antero-lateral processes of abdominal shield enormous ..... *Heterosteus* (p. 308).

Genus **COCCOSTEUS**, Agassiz.

[Poiss. Foss. V. G. R. 1844, p. 22.]

Syn. *Liognathus*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. 1873, p. 306.

Head and trunk broad, the dorsal aspect more or less arched from side to side; scutes ornamented with rounded stellate tubercles; neural and hæmal arches well calcified, and the caudal region destitute of armour. Elements of cranial shield not fused in the adult, and the occipital bones constituting less than half of its length; a distinct small median bone over the pineal region, not perforated; orbits forming broad notches, not bounded externally; sclerotic ossified; premaxilla and maxilla distinct, and one or two inner pairs of dentigerous bones in the upper jaw; mandibular rami suturally united at the symphysis, each bearing a short series of conical teeth anchylosed with the middle of its oral margin. A single median dorsal shield upon the trunk, with an inner longitudinal keel, and rounded or acutely pointed posteriorly; ventral armour of trunk well developed, consisting of two large lateral plates and two small diamond-shaped median elements, the whole shield united with the median dorsal by two dorso-lateral and two truly lateral plates; anterior dorso-lateral plate with an articulating eminence, but no forwardly directed process. A pair of short deep plates meeting in the median line immediately in advance of the ventral and lateral armour, evidently representing the pectoral arch. A single short median dorsal fin upon the anterior portion of the caudal region, without fin-rays, supported by a double series of robust, superficially ossified cartilages, equal in number to the apposed neural arches.

This is the type genus of the family, and is more completely known than any of its allies, on account of the fine state of preservation in which its remains occur in the Lower Old Red Sandstone of the North of Scotland. Since the researches of Agassiz, Hugh Miller, and Egerton, much information concerning the skeleton of the fish has been obtained and published by Pander[1] and Traquair[2]; and the accompanying figures and description are chiefly based upon the most recent memoir of the latter author.

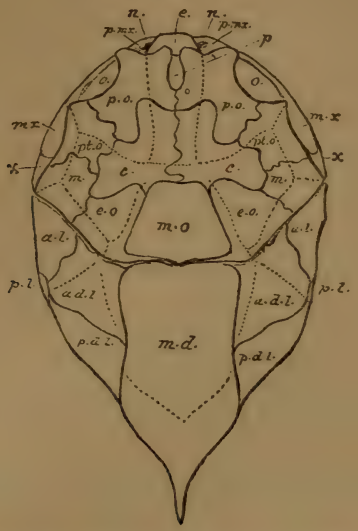
The cranial shield (fig. 42) is irregularly six-sided in shape, the

[1] C. H. Pander, Die Placodermen des devonischen Systems (St. Petersburg, 1857).

[2] R. H. Traquair, "On the Structure of *Coccosteus decipiens*, Agassiz," Ann. Mag. Nat. Hist. [6] vol. v. (1890), pp. 125–136, pl. x.

anterior lateral borders being notched by the orbits (*o.*) and the front border somewhat rounded. A large quadrangular median occipital element (*m.o.*), and a flanking pair of triangular exoccipitals (*e.o.*) form the posterior and the greater part of the posterolateral borders; the median occipital tapering anteriorly somewhat

Fig. 42.



Outline of cranial and dorsal shield of *Coccosteus decipiens*, Ag., restored by R. H. Traquair.—*a.d.l.*, anterior dorso-lateral; *a.l.*, anterior lateral; *c.*, central; *e.*, ethmoid; *e.o.*, external occipital; *m.*, marginal; *m.d.*, median dorsal; *m.o.*, median occipital; *mx.*, maxillo-suborbital; *n.*, narial opening; *o.*, orbit; *p.*, pineal; *p.d.l.*, posterior dorso-lateral; *p.l.*, posterior lateral; *p.mx.*, premaxilla; *p.o.*, pre-orbital; *pt.o.*, post-orbital; *x.*, operculum (?).

less than the exoccipitals. Immediately in front of these plates is a pair of central elements (*c.*) meeting in a wavy longitudinal suture at the mesial line; while the lateral angles of the shield are formed by a small pair of quadrangular marginals (*m.*), wedged in on each side between the exoccipital, central, and postorbital (*pt.o.*) plates. The last-named element is almost as small as the marginal, and extends partly into the upper border of the orbital notch. A pair of large preorbital plates (*p.o.*) adjoins the front margin of the centrals and postorbitals, forming the anterior two thirds of the orbital notch with the antorbital process. These plates meet in the middle line of the shield only for a short space in their hinder half,

being separated in front by a small narrow pineal plate (*p.*), which exhibits a deep pit on its under surface for the reception of the pineal body. Still further forward the shield terminates in a small, short, and broad ethmoidal plate (*e.*), of which the hinder border meets both the preorbitals and the pineal. A large bone on the cheek (fig. 42, *mx.*) sends forward a narrow process beneath the eye, and is interpreted by Pander as suborbital, by Traquair as maxilla, probably both in part with justification. A small element between this and the ethmoid is named premaxilla (*pmx.*) by Traquair, and seems to form the lower border of the narial opening (*n.*); while posterior to the so-called maxilla is a deep triangular element (*x.*) with free hinder border, not improbably to be regarded as the operculum. Within the orbit traces of a delicate ossified sclerotic ring, apparently continuous, are sometimes observable. The chondrocranium is entirely unknown, but in an allied genus, *Chelyophorus*, the parachordal cartilages are ossified, and there seem to be distinct exoccipitals; while in a single example of *Coccosteus* from Gamrie there is distinct evidence of two pairs of bones on the palate bearing conical teeth. There is also a single bone in each ramus of the lower jaw, bearing conical teeth in its middle portion, the two rami meeting loosely and denticulated on the anterior margin at the symphysis; but the supposed premaxillæ and maxillæ are toothless.

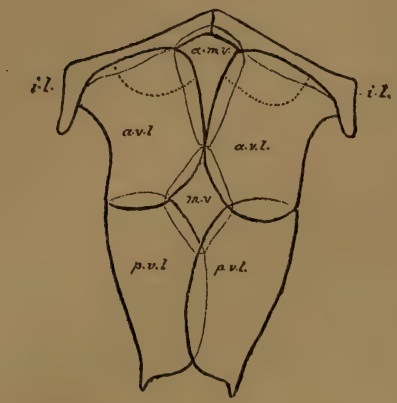
The line of separation between the cranial and abdominal armour forms a prominent cleft; and immediately in advance of the ventro-lateral plates of the trunk is a pair of clavicle-shaped elements, meeting in the middle line ventrally and termed inter-laterals (fig. 43, *i.l.*) by Traquair. An elongated, transversely arched median dorsal plate (fig. 42, *m.d.*) covers the back, and is supported upon the neural arches of the endoskeletal axis beneath by a longitudinal ridge on its attached surface. Four flattened plates, two above and two below, cover the anterior part of each side of the abdominal region, these being termed anterior and posterior dorso-laterals (*a.d.l.* and *p.d.l.*), anterior and posterior laterals (*a.l.* and *p.l.*). The anterior dorso-lateral exhibits a small rounded process on its front margin, to constitute a firm but readily movable joint with the exoccipital bone of the cranial shield; while the antero-lateral plate meets the inter-lateral and, with it, serves to connect the ventral with the lateral and dorsal armour. The ventral shield extends as far backward as the great dorsal plate, and consists of two principal pairs of elements, the anterior and posterior ventro-laterals (fig. 43, *a.v.l.* and *p.v.l.*), with a small, deeply-overlapped, diamond-shaped median ventral (*m.v.*), and a somewhat larger anterior median ventral (*a.m.v.*).

The course of the sensory canals is well marked upon the plates both of the head and trunk by deep grooves, which have often been mistaken for sutures. They were first clearly mapped by Traquair as dotted lines on the accompanying figures.

The hinder abdominal and caudal regions are destitute of armour (fig. 44), the only dermal calcification occurring in a narrow band along the lateral line (see p. 289).

A narrow vacant space in the position of the notochord bears witness to its persistence, and the tail tapers apparently in a heterocercal manner. The neural and hæmal arches are short, robust,

Fig. 43.

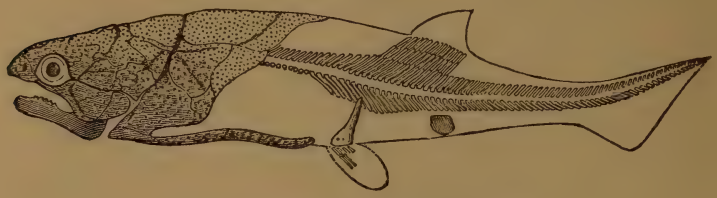


Outline of ventral armour of *Coccosteus decipiens*, Ag., restored by R. H. Traquair.—*a.m.v.*, anterior median ventral; *a.v.l.*, anterior ventro-lateral; *i.l.*, inter-lateral (? clavicle); *m.v.*, median ventral; *p.v.l.*, posterior ventro-lateral.

and closely arranged, fused with their respective spines, and all superficially calcified. There are no ribs; but immediately behind the termination of the abdominal region the neural and hæmal arches gradually become elongated for some distance, and to the ends of the long neurals in this part of the axis are apposed, in equal number, the basal cartilages of a short dorsal fin. The latter cartilages occur in two rows, a proximal and a distal, the elements all being superficially calcified and as robust as the neural spines. The fin itself was membranous, and is partly shown by an Orkney fossil (No. P. 180) mentioned below (p. 285), but still more satisfactorily in a single specimen in the University of Glasgow. There is no anal fin, and a caudal has not yet been recognized.

As already remarked, the pectoral arch seems to be represented by a large pair of dermal bones, but no appendages are observable. There is, however, distinct evidence of a hinder pair of limbs (see p. 289), and the well-developed pelvic basipterygia (fig. 44), superficially calcified, and separated in the middle line below, are often conspicuous. At the broad lower end these exhibit one or two deep pits or foramina. In each pelvic fin there is a proximal series of four or five short basal cartilages, and distal to these is another series of elongated cartilages, all robust and superficially calcified,

Fig. 44.



Coccosteus decipiens, Ag.; side view, restored.

but arranged in a manner that is not yet clearly shown: it can merely be determined that the fin possessed a well-developed base of endoskeletal elements.

A singular thin, quadrate plate, with rounded angles and prominent concentric lines of growth, also occurs in the abdominal region (fig. 44) immediately behind the much elongated hæmal arches. To the present writer it is most suggestive of an internal element of support occurring in the vertical septum between the right and left halves of some paired organ.

Coccosteus decipiens, Agassiz.

[Plate VII.]

1829. "*Trionyx*," Sedgwick & Murchison, Trans. Geol. Soc. [2] vol. iii. p. 144, pl. xvi. fig. 6.
1841. *Coccosteus*, H. Miller (*ex* Agassiz, MS.), Old Red Sandst. pl. iii.
1842. *Coccosteus latus*, L. Agassiz, Rep. Brit. Assoc. p. 87 (name only).
1842. *Coccosteus cuspidatus*, P. Duff (*ex* Agassiz, MS.), Geol. Moray, p. 69, pl. viii. fig. 1.
1844. *Coccosteus decipiens*, L. Agassiz, Poiss. Foss. V. G. R. pp. 26, 137, pl. B. figs. 2, 3, pls. vii.–x., pl. xxx. *a*. fig. 19.
1844. *Coccosteus oblongus*, L. Agassiz, *ibid.* p. 28, pl. xi. figs. 1–3, pl. xxx. *a*. fig. 2. [Imperfect skeleton; British Museum.]

1844. *Coccosteus cuspidatus*, L. Agassiz, *ibid.* pp. 28, 137, pl. xxxi. fig. 4. [Median dorsal plate; Edinburgh Museum.]
1848. *Coccosteus microspondylus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 298. [Imperfect skeleton; Woodwardian Museum.]
1848. *Coccosteus pusillus*, F. M'Coy, *ibid.* p. 298. [Ditto.]
1848. *Coccosteus ? trigonaspis*, F. M'Coy, *ibid.* p. 299. [Ditto.]
1855. *Coccosteus latus*, F. M'Coy, Brit. Palæoz. Foss. p. 602.
1855. *Coccosteus oblongus*, F. M'Coy, *ibid.* p. 603.
1855. *Coccosteus microspondylus*, F. M'Coy, *ibid.* p. 602, pl. ii. c. fig. 4.
1855. *Coccosteus pusillus*, F. M'Coy, *ibid.* p. 603, pl. ii. c. fig. 5.
1855. *Coccosteus ? trigonaspis*, F. M'Coy, *ibid.* p. 603, pl. ii. c. fig. 6.
1860. *Coccosteus decipiens*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xvi. p. 128.
1860. *Coccosteus milleri*, Sir P. Egerton, *ibid.* p. 135, woodc. figs. 5, 6. [Edinburgh Museum.]
1875. *Coccosteus decipiens*, W. H. Baily, Figs. Charact. Brit. Foss. pl. xxxiii. fig. 3.
1880. *Brachydeirus milleri*, A. von Koenen, Zeitschr. deutsch. geol. Ges. vol. xxxii. p. 675.
1883. *Brachydeirus milleri*, A. von Koenen, Abh. phys. Cl. k. Ges. Wiss. Göttingen, vol. xxx. p. 20.
1883. *Brachydeirus pusillus*, A. von Koenen, *ibid.* p. 20.
1888. *Coccosteus decipiens*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 511.
1889. *Coccosteus decipiens*, R. H. Traquair, *ibid.* vol. vi. p. 4, pl. i. fig. 2.

Type. Imperfect skeletons; British Museum.

The type species, attaining a maximum length of about 0·4. Cranial shield hexagonal in form, the outer lateral angles acute, and the breadth between the latter considerably greater than the total length; median occipital much broader than long, abruptly truncated in front, its anterior end being only half as broad as the posterior; the anterior two-thirds of the shield gradually arched from side to side, flattened or depressed above, and the posterior portion of the median occipital plate rising to a sharply bent longitudinal ridge, corresponding to the laterally-arched contour of the median dorsal plate of the trunk immediately behind. Median dorsal plate as long as the cranial shield, and twice as long as broad, much arched from side to side, gradually tapering in its posterior half and produced into a long, blunt point; anterior border slightly excavated. Anterior ventro-lateral plates not much longer than broad, shorter than the posterior ventro-laterals, which are twice as long as broad and produced at each postero-lateral angle into a short spine; exposed portion of both median ventral plates longer than broad, the lateral angulation of the posterior median being almost at its middle point. Tuberculations of moderate size, never confluent, and rarely, except in the lateral plates,

arranged in definite lines. Unarmoured caudal region somewhat longer than the head and armoured portion of the trunk; dorsal fin with about fifteen double series of endoskeletal supports, arising at a distance equal to its own length behind the great dorsal plate.

Form. & Loc. Lower Old Red Sandstone: Banffshire, Nairnshire, Cromarty, Ross-shire, Caithness, and Orkney[1].

(i.) Orkney Isles (typical *C. decipiens*).

P. 3214–5. Two of the type specimens figured by Agassiz, *op. cit.* pl. vii. and pl. ix. fig. 2. The relative elongation of the hæmal arches in the abdominal region is conspicuous, and in the second specimen the double series of supporting bones of the dorsal fin is distinct. The latter fossil also exhibits remains of a longitudinal grooved streak (calcified lateral line) along the vacant space originally occupied by the notochord; and appearances on the ventral aspect are suggestive of the radial cartilages of a pelvic fin attached to a small arched basipterygium. *Enniskillen Coll.*

P. 535, P. 535 a, P. 536 a. Two of the type specimens, the first in counterpart and figured, *op. cit.* pl. viii. pl. ix. fig. 1, the second figured, *op. cit.* pl. ix. fig. 3. The anterior dorso-lateral plates in the former exhibit the rounded articular process on the inner margin. The apparently curved process of the posterior outer angle of the posterior ventro-lateral plate is an impression of the small curved pelvic basipterygium. *Egerton Coll.*

P. 536. Posterior median ventral plate, figured by Agassiz, *op. cit.* pl. xxx. *a.* fig. 19. *Egerton Coll.*

P. 3216, P. 3216 a. Two slabs from Ramna Gio, each with an imperfect specimen and the crushed carapace of another. The second specimen displays the double series of about twelve supporting bones of the dorsal fin and a fragment evidently of the fin-membrane itself; also one of the pelvic basipterygia and a fragment of indeterminable fossilized tissue in the anal region. *Enniskillen Coll.*

P. 550. Portion of trunk, showing dorsal fin-supports, the elongation of the abdominal hæmal arches, and an indeterminable patch of tissue in the anal region. *Egerton Coll.*

[1] This species is also considered to occur in the Russian Devonian by E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1522.

P. 687–8. Two specimens, one showing the impressions of several plates and nearly all the axial skeleton of the trunk and tail, the other considerably resembling No. P. 536 *a*, though with only half of the caudal region. The first specimen was obtained from Ramna Gio, the second from Belyacreugh. *Egerton Coll.*

P. 180. A well-preserved skeleton showing portions of the double series of supporting bones and membrane of the dorsal fin, one of the pelvic elements, and a quadrate patch of tissue in the anal region. The median dorsal plate, the left dorso-laterals, laterals, and ventro-laterals are especially well displayed. *Purchased*, 1881.

P. 181. Small more imperfect individual, similarly crushed. *Purchased*, 1881.

43966. Crushed individual, imperfectly preserved, displaying the supporting bones of the dorsal fin. The armoured portion measures about 0·17 in length, and the unarmoured caudal region 0·205. *Purchased*, 1872.

P. 5964–65. Two crushed specimens, the first showing possible traces of a pelvic fin, the second with the pelvic basipterygium. *Purchased*, 1889.

20645. Nearly complete individual, imperfectly preserved; Stromness. *Purchased*, 1846.

P. 4310. Six portions of dermal armour, detached from matrix. *Enniskillen Coll.*

P. 691. Imperfect detached mandibular ramus, partly in impression; Belyacreugh. This and the following specimen are probably referred to by Newberry (Palæoz. Fishes N. America, 1889, p. 132) as closely resembling the mandibular rami of *Dinichthys*. The beak-like appearance, however, is due entirely to the accidental flaking of the bituminous substance into which the fossils are converted. *Egerton Coll.*

P. 3217. Similar jaw. *Enniskillen Coll.*

P. 4310 a. Detached mandibular ramus, showing teeth and two of the anterior denticulations. *Enniskillen Coll.*

P. 692. Median ventral plate of small individual. *Egerton Coll.*

(ii.) Caithness.

49663. Imperfect remains of a very large individual, displaying the same aspect as the two last-mentioned specimens; Holburn Head. *Purchased*, 1879.

20646. Median dorsal plate and imperfectly preserved caudal region. *Purchased*, 1846.

(iii.) Edderton, near Tain, Ross-shire.

38727. Imperfect head, dorsal aspect, and several portions of plates of the trunk. *Purchased*, 1865.

39696. Inferior aspect of imperfect cranial roof. *Purchased*, 1866.

P. 695, P. 1171. Roof of skull, imperfect laterally; also the impression of a similar specimen associated with a mandibular ramus and portions of the plates of the trunk. *Egerton Coll.*

P. 5600. Less imperfect example, with displaced maxillaries and premaxillaries, one of the latter apparently exhibiting the notch interpreted as nasal by Traquair. The specimen also exhibits one of the anterior dorso-lateral plates. *Harford Coll.*

38728. Crushed median dorsal plate, associated with portions of other plates, fragments of the axial skeleton, and a small undetermined, almost reniform element, apparently unornamented. *Purchased*, 1865.

41729. Imperfect median dorsal plate, probably uncrushed, associated with portions of other plates. In the median dorsal the rounded longitudinal keel only extends along the posterior two-thirds of the bone, the surface sloping downwards both in front and on each side of its commencement. *Purchased*, 1869.

P. 695 a, P. 1171 a. Portions of the dorsal and ventral plates of the trunk, with the supporting bones of the dorsal fin and part of the axial skeleton, in counterpart. Remains of the pelvic elements are distinguishable, and in the abdominal region the small unornamented plate, figured below in No. 43617, is exhibited. *Egerton Coll.*

P. 1171 b, P. 3220 a. Ventral plates of trunk, with remains of dorsal and lateral plates, in counterpart. *Egerton & Enniskillen Colls.*

P. 6074. Several associated imperfect plates of the trunk. *Presented by F. Harford, Esq.*, 1889.

(iv.) Cromarty (*C. decipiens*).

41728. Cranial shield, upper aspect, considerably broken. *Purchased*, 1869.

P. 3220. Similar specimen. *Enniskillen Coll.*

P. 696. Plaster cast of mandibular rami, showing anterior denticulations, the original specimen in the Edinburgh Museum, and probably the basis of Miller's description (Old Red Sandst. p. 57). *Egerton Coll.*

19057–58, 19069. Three specimens showing various plates, chiefly of the trunk, the third also exhibiting portions of mandible and teeth. *Purchased*, 1845.

20649, 20651–52. Remains of median dorsal plate showing inner longitudinal ridge, bifurcated inferiorly; also a similar crushed plate, in counterpart. *Purchased*, 1846.

30872–73. Median dorsal and posterior ventro-lateral plates, the second preserved in counterpart. *Purchased*, 1856.

P. 5062. Median dorsal plate. *Presented by J. E. Lee, Esq.*, 1885.

(v.) Lethen Bar (typical *C. oblongus*).

P. 3222–23. Type specimens of *Coccosteus oblongus*, figured by Agassiz, *op. cit.* pl. xi. *Enniskillen Coll.*

P. 685 a, P. 3224 a. Dermal armour of head and trunk, imperfectly preserved, in counterpart. Teeth are observed in the mandible, relatively more slender than those of No. P. 3222. *Egerton & Enniskillen Colls.*

P. 3224. Three examples of the head and portions of the dermal armour of the trunk. Two specimens seem to indicate the presence of a deep pit on the inferior aspect of the so-called posterior ethmoid plate (described above as pineal). *Enniskillen Coll.*

P. 685 b, P. 2078. Two examples of the head and armoured portion of the trunk, with fragments of the axial skeleton, the second also showing the small thin plate in the abdominal region already noted in Nos. P. 3216, P. 550, P. 180, 38728, and P. 695 *a*. *Egerton Coll.*

P. 685. Ten specimens exhibiting plates of the head and trunk. *Egerton Coll.*

49185–86. Two specimens of the head and armoured trunk, in counterpart. Broad teeth are shown in the mandible of both specimens. *Purchased*, 1876.

21574, a, b. Three examples of the dermal plates of the head and trunk, the second and third being preserved in counterpart. In the first specimen the median occipital of the cranial shield exhibits the characteristic median elevation, and the "posterior ethmoidal" (pineal) shows a distinct cast of the large central pit on its inferior aspect. *Presented by Norman McLeod, Esq.*, 1847.

20792 a–b. Fine example of the dermal plates of the head and trunk, preserved in counterpart. The maxillary or suborbital elements are displaced, and the supposed operculum is observed immediately behind on each side. The tubercular ornament is very coarse; and behind the median dorsal plate there occurs one of the pelvic basipterygia. *Presented by Col. Sir Proby T. Cautley, K.C.B., and — Gordon, Esq.*, 1847.

P. 5960–1. Two specimens showing various dermal plates, the first including the mandibular rami with teeth. *Purchased*, 1889.

P. 685 c. Median dorsal plate, broken to exhibit the extent of the inner longitudinal keel. *Egerton Coll.*

P. 5060. Median dorsal plate. *Presented by J. E. Lee, Esq.*, 1885.

P. 6073. Median dorsal plate with imperfect portions of other elements. *Presented by F. Harford, Esq.*, 1889.

P. 3225. Crushed median dorsal plate. *Enniskillen Coll.*

(vi.) Tynet Burn.

43617. Imperfect individual wanting the posterior half of the caudal region, lateral aspect, in counterpart. The dermal plates of the head and trunk are much broken, but several characteristic elements are exhibited; while the region immediately behind the armour is especially well preserved. The latter is shown, of the natural size, in Pl. VII. fig. 2, and the parts are lettered in accordance with the following description. Emerging from beneath the median dorsal

plate (*d.*) is the closely arranged series of robust neural arches with their spines (*n.*), bounding above the narrow vacant space (*not.*) originally occupied by the persistent notochord; and some of these arches exhibit indications of a zygapophysial union. Below the notochordal space there is a corresponding series of hæmal arches and spines (*h.*), gradually becoming much lengthened towards the end of the abdominal region and shortening again in the caudal. A short distance behind the dorsal shield the neural spines also become lengthened for the support of the double series of about 13 basal cartilages (b^1, b^2) of the dorsal fin, which are as robust as the neural spines themselves and are directly apposed to the ends of an equal number of the latter. The membrane of the dorsal fin is not observed, but remains of a small *Diplacanthus* occur in the position it would originally occupy. Behind and above the posterior ventro-lateral plates (*p.v.l.*) are preserved the right and left pelvic basipterygia (*plv.*), attenuated above, but widened to a club-shaped extremity below, with one or two deep pits or foramina (*f.*) penetrating this expansion. Apposed to the broad end of one of these cartilages is a series of four or five short stout rays (*r.*), while directly behind the same cartilage are indications apparently of longer rays of a similar character (see also No. P. 3215); these, like all the other endoskeletal elements, being only calcified in a thin layer at the surface. Portions of a longitudinal white streak (*l.l.*) along the vacant space between the neural and hæmal arches are suggestive of dermal calcifications along the lateral line (see also No. P. 3215); and the problematical azygous plate (*x.*) at the commencement of the caudal region, already noted in several specimens, is especially conspicuous. This plate is quadrate in form, with a convex inferior border, is evidently very thin, and exhibits prominent concentric lines of growth. *Purchased*, 1872.

44586. Cranial shield, with displaced maxillo-suborbitals, in counterpart, shown of the natural size in Pl. VII. fig. 1. The specimen is apparently uncrushed, thus exhibiting the original contour; most of the sutures and some of the sensory canals are distinct, and are seen to be disposed as in Dr. Traquair's restoration (fig. 42, p. 279); and the superficial tuberculations are unusually coarse.

Purchased, 1873.

35776, P. 6266. Median dorsal plate, in counterpart.
Purchased, 1869, *and Enniskillen Coll.*

43277. Imperfect median dorsal plate, showing keel.
Purchased, 1871.

(vii.) Gamrie (typical *C. cuspidatus*).

28861-a. Two examples of the cranial shield, dorsal aspect, considerably fractured. *Purchased*, 1854.

39177. Crushed remains of dermal plates of head and trunk.
Bowerbank Coll.

47867. Much crushed and broken dermal plates of head and trunk, with a few of the neural and hæmal arches and dorsal fin-supports, lateral aspect, preserved in counterpart. Some of the teeth are of the broad, blunt type described as characteristic of *C. oblongus*; and the hinder outer angles of the posterior ventro-lateral plates are produced into unusually long spines. *Purchased*, 1877.

P. 694, P. 3218-9. Specimen exhibiting several plates, including the inner aspect of an anterior dorso-lateral; also three imperfect cranial shields, with other plates, in counterpart.
Egerton & Enniskillen Colls.

P. 4926. Remains of various plates of the head and trunk, partly in counterpart. *Presented by Prof. J. Prestwich*, 1885.

39178. Fractured dermal bones. *Bowerbank Coll.*

28861 b. Hinder extremity of armour of trunk, with remains of the neural and hæmal arches of the axial skeleton.
Purchased, 1854.

The following specimens are noticed in the letters by Hugh Miller, quoted in Quart. Journ. Geol. Soc. vol. xvi. (1860), pp. 128-136:—

P. 5143. Series of eight plaster casts, figured *loc. cit.*, woodcuts 1-6, 8, 9. *Egerton Coll.*

P. 5144. Paper model of tail of *Coccosteus*, as interpreted by Miller, figured *ibid.* p. 134, woodcut 7. *Egerton Coll.*

Coccosteus minor, Miller.

1858. *Coccosteus minor*, H. Miller, 'Cruise of the Betsey,' etc. p. 396.
1888. *Coccosteus minor*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 511.
1889. *Coccosteus minor*, R. H. Traquair, *ibid.* vol. vi. p. 8, pl. i. fig. 3.

Type. Imperfect skeletons; Edinburgh Museum.

A very small species, attaining a maximum total length of about 0·1. Cranial shield broader than long; mandibular teeth very slender and sharply pointed; infra-orbital bar of maxillo-suborbital bone relatively deep. Median dorsal plate about twice as long as broad, somewhat arched from side to side, gradually tapering in its posterior half into a long, blunt point; anterior border slightly excavated, and the granulations much finer along the mesial longitudinal line of the shield than at its sides. Posterior ventro-lateral plates twice as long as broad, produced at each postero-lateral angle into a short spine. Tuberculations numerous, of moderate size, never confluent, and not arranged in definite lines. Unarmoured caudal region about equal in length to the head and armoured portion of the trunk.

As remarked by Hugh Miller, the remains of individuals of this species occur in groups, at first sight suggestive of their being shoals of young.

Form. & Loc. Lower Old Red Sandstone: Caithness and Orkney.

42383. Three imperfect associated individuals; Murkle Bay, Caithness. *Peach Coll.*

42385. Remains of two or more individuals on one slab, showing stout well-ossified neural and hæmal arches of axial skeleton; Murkle Bay. *Peach Coll.*

42384, 42387–89. Four small slabs with scattered dermal plates; Murkle Bay. The second specimen exhibits a mandibular bone with teeth. *Peach Coll.*

42386. Imperfect median dorsal plate, ventral aspect; Thurso. *Peach Coll.*

P. 689. Slab with scattered dermal plates of several individuals, probably of this species; Orkney. *Egerton Coll.*

P. 3221–a. Two slabs with scattered dermal plates; Orkney. The second specimen shows an imperfect median dorsal plate exhibiting some of the characters stated in the diagnosis. *Enniskillen Coll.*

Coccosteus disjectus, sp. nov.

[Plate VIII. figs. 1–4.]

Type. Associated median ventral plates; British Museum.

An imperfectly known species of moderate size. Anterior median ventral plate much broader than long, its obtuse posterior angle completely exposed and overlapping the anterior border of the median ventral; median ventral nearly twice as long as broad, its anterior extremity truncated, and its lateral angulation situated much behind the middle point. Posterior ventro-lateral plates nearly two-thirds as broad as long. Tuberculations of moderate size, having a somewhat radiating arrangement upon the anterior median ventral plate.

Form. & Loc. Upper Old Red Sandstone: Kiltorcan, Kilkenny, Ireland.

43039. Type specimen exhibiting the form and proportions of the associated median ventral plates, shown, of the natural size, in Pl. VIII. figs. 1, 2. In fig. 2 the anterior extremity has been inadvertently directed downwards.
Purchased, 1871.

P. 3226–a. Two similar plates more imperfectly preserved.
Enniskillen Coll.

41901. Right posterior ventro-lateral plate, inner aspect, shown, of the natural size, in Pl. VIII. fig. 3. *Purchased*, 1870.

43039 a. Fragment of plate, with ornamentation, partly shown, of twice the natural size, in Pl. VIII. fig. 4.
Purchased, 1871.

Coccosteus hercynius, H. von Meyer.

1852. *Coccosteus hercynius*, H. von Meyer, Palæontogr., vol. iii. p. 82, pl. xii. fig. 28.

Type. Associated dermal plates.

An imperfectly known species, nearly equal to the typical *C. decipiens* in size. Median occipital scarcely broader than long. Median dorsal plate less than twice as long as broad, the anterior border excavated, and the posterior border rounded. Posterior ventro-lateral plates more than three times as long as broad, much longer than the median dorsal. Tuberculations large, numerous, never confluent.

Form. & Loc. Lower Devonian: Harz Mts.

P. 6267. Two imperfect ventro-lateral plates, doubtfully of this species; Goslauer Schiefer, Huuthal. *Purchased.*

The following portions of median dorsal plates of *Coccosteus* exhibit the internal longitudinal ridge as strongly developed as in a specimen from Livonia figured by Pander [1], and are ascribed by Trautschold to a species supposed to possess pectoral appendages, under the name of *Coccosteus megalopteryx*, Trautschold [2]. If the pectoral appendages are correctly associated with the plates, the species does not pertain to *Coccosteus*; if not, the specific name is too inapplicable for adoption.

P. 4731. Two fragments of the posterior portion of the median dorsal element, and one specimen showing the greater portion of the internal longitudinal ridge; Devonian, River Ssjass, Govt. of St. Petersburg. *Purchased*, 1884.

The following specimen is specifically undetermined:—

P. 5282. Imperfect median dorsal plate described and figured in Geol. Mag. [2] vol. vii. (1880), p. 146, pl. v. fig. 3; Upper Devonian, near Chudleigh, S. Devon.
Presented by John Edward Lee, Esq., 1885.

The following species have also been described, but are not represented in the Collection:—

Coccosteus obtusus, H. Trautschold, Zeitschr. deutsch. geol. Ges. vol. xli. (1889), p. 44, pl. v. figs. 7–9, pl. vi. figs. 1, 2 (? in part).—Devonian; Ssjass, Russia. [Imperfect detached plates; Trautschold Coll., Breslau.]

Coccosteus occidentalis, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 32, pl. liv. fig. 2.—Corniferous Limestone (Lower Devonian); Delaware, Ohio. [Dorsal plate; Columbia College, New York.]

As remarked by Newberry (Palæoz. Fishes N. America, p. 52), it seems not unlikely that to the latter species must be referred the mandibular ramus named *Liognathus spatulatus*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 306, pl. xxix. fig. 4. This is also preserved in the Museum of Columbia College.

[1] C. H. Pander, Placoderm. devon. Syst. (1857), pl. B. fig. 4.

[2] H. Trautschold, Verhandl. russ.-kais. mineral. Gesell. [2] vol. xv. (1880), p. 145, pls. vi., ix., x.; also Zeitschr. deutsch. geol. Gesell. vol. xli. (1889), p. 35, pls. iii., iv., pl. v. figs. 1–6.

Dermal plates of Placoderms, too imperfect for satisfactory determination, have also been assigned to *Coccosteus* under the following names:—

Coccosteus agassizi, J. Barrande, Syst. Silur. Bohême, vol. i. suppl. (1872), p. 638, pl. xxix. figs. 3, 4, 6–8.—Upper Silurian (**g 1**); Chotecz, Bohemia. [Royal Bohemian Museum.]

Coccosteus fritschi, J. Barrande, *ibid.* (1872), p. 639, pl. xxx. figs. 1–6.—Upper Silurian (**g 1**); Schwagerka quarry, Hluboček, Bohemia. [? *Aspidichthys.*] [Royal Bohemian Museum.]

Coccosteus obtusus, C. H. Pander, in A. von Keyserling, Reise in das Petschoraland (1846), p. 292 *b*.—Devonian; River Uchta, Petchora Land.

Coccosteus obtusus, A. von Koenen (*non* Pander), Abh. phys. Cl. k. Gesell. Wiss. Göttingen, vol. xxx. (1883), p. 10; Verhandl. natur. Verein. preuss. Rheinl. etc. vol. xliii. (1886), p. 55, woodc. 1, 2: *Brachydeirus obtusus*, A. von Koenen, *tom. cit.* (1883), p. 21.—Upper Devonian; Wildungen, Bicken, and Müllenborn, Eifel. [? *Holonema.*]

Coccosteus primus, J. Barrande, *tom. cit.* (1872), p. 640, pl. xxix. figs. 1, 2.—Upper Silurian (**f 2**); Konieprus, Bohemia. [Royal Bohemian Museum.]

Genus **BRACHYDIRUS**, A. von Koenen.

[Zeitschr. deutsch. geol. Ges. vol. xxxii. 1880, p. 675, and Abh. phys. Cl. k. Ges. Wiss. Göttingen, vol. xxx. 1883, p. 20 (as subgenus of *Coccosteus*).]

Shield of head and abdominal region closely resembling that of *Coccosteus*, but more laterally compressed. Pectoral limbs represented by a slender, hollow spine. (*A. von Koenen.*)

Some doubtful diagnostic characters are also noticed by von Koenen in the suture between the cranial and abdominal shields. As remarked by Traquair[1], the presence of a pectoral spine suffices to distinguish this form generically from *Coccosteus*, in the typical species of which no such appendage exists.

The following species are recognized:—

Brachydirus bickensis: *Coccosteus bickensis*, A. von Koenen, Zeitschr. deutsch. geol. Ges. vol. xxviii. (1876), p. 667, and *ibid.* vol. xxxii. (1880), p. 673, and Abh. phys. Cl. k.

[1] Geol. Mag. [3] vol. vii. (1890), p. 235.

Ges. Wiss. Göttingen, vol. xxx. (1883), p. 17, pl. i. fig. 3, pl. ii. fig. 2, pl. iv. figs. 5, 7.—Upper Devonian; Bicken, Eifel.

Brachydirus bidorsatus, A. von Koenen, Abh. phys. Cl. k. Gesell. Wiss. Göttingen, vol. xxx. (1883), p. 28, pl. i. figs. 2, 4: *Coccosteus bidorsatus*, A. von Koenen, Zeitschr. deutsch. geol. Gesell. vol. xxxii. (1880), p. 674.—Upper Devonian; Bicken.

Brachydirus carinatus, A. von Koenen, *ibid.* (1883), p. 31, pl. ii. fig. 1: *Coccosteus carinatus*, A. von Koenen, *tom. cit.* (1880), p. 673.—Upper Devonian; Bicken.

Brachydirus inflatus, A. von Koenen, *tom. cit.* (1880), p. 674, and *tom. cit.* (1883), p. 26, pl. i. fig. 1, pl. iv. figs. 1, 2, 3, 6.—Upper Devonian; Bicken.

The type specimens are preserved in the Royal Geological Museum, Göttingen.

Genus **PHLYCTÆNASPIS**, Traquair.

[Geol. Mag. [3] vol. vii. 1890, pp. 60 (*Phlyctænius*[1]), 144.]

Head and trunk broad, the dorsal aspect more or less arched from side to side; scutes ornamented with stellate tubercules, and those of the upper surface of the head also marked with deep sensory furrows. Elements of cranial shield, except the rostral bone, fused together in the adult, and the occipital bones constituting not more than half of its total length; median occipital elongated antero-posteriorly, and its anterior end produced between the divergent hinder extremities of the pair of central plates; no median element over the pineal region, and no foramen; orbits forming broad notches, not bounded externally. [Arrangement of plates upon trunk unknown, but probably as in *Coccosteus*.]

So far as known, the species of this genus do not exceed those of *Coccosteus* in size.

Phlyctænaspis acadica (Whiteaves).

1881. *Coccosteus acadicus*, J. F. Whiteaves, Canadian Nat. n. s. vol. x. p. 94, woodc.

1889. *Coccosteus acadicus*, J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 93, woodc. fig. 2, pl. ix.

1890. *Phlyctænaspis acadicus*, R. H. Traquair, Geol. Mag. [3] vol. vii. pp. 20, 60, pl. iii. figs. 1, 2.

Type. Cranial shield and detached plates; Geol. Survey of Canada, Ottawa.

[1] Non *Phlyctænium*, Zittel, Neues Jahrb. 1878, p. 62.

The type species. Cranial shield ovoid in form, truncated at its hinder border, the outer lateral angles rounded and notched, and the breadth between the latter about equal to the total length; the anterior two-thirds of the shield gradually arched from side to side, flattened or depressed mesially, the posterior portion of the median occipital plate rising to a broad, low, longitudinal ridge, corresponding to the laterally arched contour of the median dorsal plate of the trunk immediately behind. Median dorsal plate about three times as long as broad, convex in the median line, but highest in the centre, from which point there is a downward slope in every direction, the lateral slopes being most abrupt; anterior border not excavated; the sides parallel for more than two-thirds of their length, then converging rapidly into a point with somewhat concave sides. Tuberculations of small or moderate size, often arranged in close, concentric series, especially upon the laterally situated plates.

Form. & Loc. Lower Devonian: Campbellton, New Brunswick.

P. 5474–75, P. 5972. Three imperfect cranial shields, the first about 0·1 in maximum breadth, the second and third displaying the linear arrangement of the tubercles.

Purchased, 1888, 1889.

P. 5973. Imperfect plate of the form named "ventro-median (?)" by Whiteaves, but appearing to the present writer to be the anterior lateral element. *Purchased*, 1889.

Phlyctænaspis anglica, Traquair.

[Plate VIII. figs. 5–8.]

1870. *Zenaspis* (*Cephalaspis*) *salweyi*, E. R. Lankester (*errore*), Fishes Old Red Sandst. pt. i. (Pal. Soc.), p. 55, pl. viii. fig. 4 (? figs. 2, 3), pl. xiii. figs. 17, 18.

1890. *Phlyctænius anglicus*, R. H. Traquair, Geol. Mag. [3] vol. vii. p. 85, pl. iii. figs. 3, 4.

Type. Imperfect cranial shield; Edinburgh Museum.

Cranial shield ovoid in form, truncated at its hinder border, the outer lateral angles rounded, but not notched, and the breadth between the latter about equal to the total length. Tuberculations of cranial plates relatively very large, but irregular both in size and arrangement, rarely in concentric series; those of the supposed ventral body-plates exhibiting a more or less definite concentric serial arrangement, and some of the rows very minute.

Some fragments of this species were assigned by Lankester to undetermined positions in the dermal armature of *Cephalaspis salweyi*;

and a bilaterally symmetrical ridge-scute, having a similar ornament, was regarded as occupying an anterior position on the dorsal aspect of the trunk of the same fish. The latter fossil may be the dorsal plate of *Phlyctænaspis anglica*, but its determination still remains uncertain.

Form. & Loc. Lower Old Red Sandstone (Cornstones): Herefordshire.

42147. Cranial shield, imperfect postero-laterally, chiefly shown as an impression of the outer aspect upon the matrix; Cradley. The specimen is noticed by Traquair, *loc. cit.* p. 59, pl. iii. fig. 4, and is also shown, of the natural size, in Pl. VIII. fig. 5. The excavation for the median rostral plate is distinct anteriorly, and there are faint traces of the sutures between the preorbital (*p.o.*), central (*c.*), and median occipital (*m.o.*) plates. The outlines of some of the lateral plates may also possibly be distinguishable; and the principal lateral grooves for the sensory canals are very prominent. The coarse, irregular nature of the ornamentation is well displayed, and most of the tubercles are broken in the depressions they leave in the matrix.

Baugh Coll.

37388. Greater portion of cranial shield, exhibited partly from the inner aspect, partly in impression of the external tuberculated surface, and shown, of the natural size, in Pl. VIII. fig. 6; Heightington, Worcestershire. The small, transversely elongated rostral plate (*r*) is retained in position and exhibits a somewhat finer and closer granulation than the other elements; it is almost oval in form, with pointed lateral extremities. The closed sutures between the preorbital (*p.o.*), central (*c.*), and median occipital (*m.o.*) bones are also distinct; and the lateral grooves of the sensory canal-system exhibit their usual prominence.

Purchased, 1863.

37388 a. Fragmentary cranial shield, with some of the faintly stellate tubercles disengaged from matrix; Heightington.

Purchased, 1863.

38032. Imperfect cranial shield, wanting rostral plate, shown chiefly as an impression of the external aspect; Heightington. *Purchased*, 1864.

42146. Fragmentary impression of larger specimen; Herefordshire. *Baugh Coll.*

38032 a. Portion of shield; Heightington. *Purchased*, 1864.

38032 b. Fragment with impression of tubercular ornament, exhibiting a tendency towards a concentric arrangement, and partly shown, of the natural size, in Pl. VIII. fig. 7; Heightington. *Purchased*, 1864.

37388 b. Imperfect flat plate, shown, of the natural size, in Pl. VIII. fig. 8, and probably referable to the ventral armature of the trunk. Two of the four borders of the plate are apparently thicker than the others, are unbroken, and meet in a wide, rounded angle; the tubercles are arranged in series concentric with these borders for some distance towards the centre of the plate, and gradually decrease in size until they become very small inwards.

37388 c, 38032 c. Two nearly similar plates; Heightington. *Purchased*, 1864.

The following is a bilaterally-symmetrical ridge-plate, resembling that assigned to *Zenaspis* by Lankester, *op. cit.* pl. viii. figs. 2, 3; reasoning from the shape of the plate and the character of its ornamentation, it may well be the dorsal shield of the trunk of *Phlyctænaspis anglica*.

38032 d. Internal cast of shield, with fragments of the bony tissue and its characteristic ornamentation preserved at what appears to be the hinder extremity; Heightington. There are remains of an inner longitudinal keel, apparently resembling that of the median dorsal plate in *Coccosteus*. *Purchased*, 1864.

The following specimens from the Lower Old Red Sandstone of Herefordshire may also pertain to Coccosteidæ related to *Phlyctænaspis*, but their determination is quite uncertain:—

P. 194. An oval plate, exposed from the inner aspect, truncated at one extremity, measuring 0·095 in length and 0·063 in maximum breadth. There is a longitudinal median elevation in one half of the shield, and an impression of part of the outer aspect shows that it was coarsely tuberculated. *Weaver-Jones Coll.*

P. 5274. Two small ridge-scutes, probably of an imbricating series, and externally ornamented with large tubercles; Cradley. One specimen is shown, of the natural size, in Pl. VIII. fig. 9. *Purchased*, 1885.

Fragments of the shield of an undetermined species of *Phlyctænaspis*, with an ornamentation much resembling that of *P. anglica*, have also been discovered in the Lower Devonian of Russian Poland (*Coccosteus*, A. von Alth, Abhandl. k. k. geol. Reichsanst. vol. vii. pt. i. 1874, p. 38, pl. iii. figs. 16-21).

Genus **CHELYOPHORUS**, Agassiz.

[Poiss. Foss. V. G. R. 1845, p. 135.]

Dorsal shield arched from side to side; scutes ornamented with granulations, more or less elongated, confluent, and often arranged in sinuous or vermiculating lines; neural and hæmal arches well calcified, and the caudal region destitute of armour. Elements of cranial shield not fused in the adult, and the occipital bones constituting less than half of its length; orbits forming broad notches, not bounded externally; a median pineal foramen; parachordal cartilage ossified; [jaws unknown]. Dermal armour of trunk probably as in *Coccosteus*.

This genus comprises species of small or moderate size, and does not appear to be represented in the Collection. The finest specimen hitherto described is the imperfect head and trunk of *C. primigenius* in the University of St. Petersburg; this showing one of the supporting cartilages of the dorsal fin, interpreted by Eichwald as a dorsal fin-spine. There is no certain evidence of paired appendages. Several detached plates have been described and figured by Pander (Placoderm. devon. Syst. p. 86, pl. vii. figs. 3, 9–15, 31), and compared with the corresponding plates of other genera; and the following species are recognized:—

Chelyophorus primigenius, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1525, pl. lvii. figs. 1–3.—Devonian; Govt. of Orel. [Imperfect skeleton; University of St. Petersburg.]

Chelyophorus verneuili, L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 135, pl. xxxi. *a*. figs. 14–19; G. Fischer de Waldheim, Bull. Soc. Imp. Nat. Moscou, vol. xxv. (1852), pt. i. p. 172, pl. ii. figs. 1–5; E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1529; C. H. Pander, Placoderm. devon. Syst. (1857), p. 96; H. Trautschold, Zeitschr. deutsch. geol. Ges. vol. xli. (1889), p. 46, pl. vi. figs. 3-6.—Devonian; Govt. of Orel and Livonia. [The type species, founded on detached plates.]

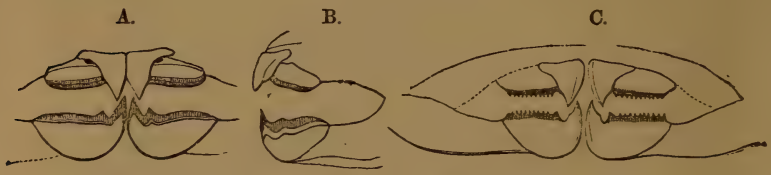
By E. von Eichwald (*tom. cit.* p. 1529, pl. lvii. figs. 4, 5), the originals of Pander's pl. vii. figs. 3, 9, 15, are assigned to *C. verneuili*; while those of the latter author's pl. vii. figs. 3 *b*, *b'*, 11, 12, 14, with an indeterminable fragment named "plaque dentaire," are regarded as the types of a distinct species, *C. posthumus*. The so-called *C. griffithii*, M'Coy (Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 8), from the Lower Carboniferous of Cultra, Co. Down, Ireland, is a generically indeterminable jaw (C. H. Pander, *op. cit.* p. 87). [Dublin Museum.]

Genus **DINICHTHYS,** Newberry.

[Rep. Geol. Surv. Ohio, vol. i. pt. ii. 1873, p. 313.]

Head and trunk broad, the dorsal aspect slightly arched from side to side; scutes smooth or feebly marked with vermiculating rugæ; caudal region destitute of armour. Elements of cranial shield almost or completely fused in the adult, and the occipital bones constituting less than half of its total length; a distinct small median bone over the pineal region, with a minute perforation; orbits forming broad notches, not bounded externally; eye with a ring of few sclerotic plates; maxilla distinct, and two inner pairs of dentigerous bones in the upper jaw; mandibular rami suturally united at the symphysis, each beak-shaped in front, and bearing a short, single series of

Fig. 45.



Diagrams of dentition of *Dinichthys*, after Newberry.—A, anterior, and B, lateral aspect of jaws of *D. terrelli*; C, anterior aspect of jaws of *D. hertzeri*.

acute teeth anchylosed just in advance of the middle of its oral margin. A single median dorsal shield upon the trunk, with an inner longitudinal keel, and rounded or acutely pointed posteriorly; ventral armour of trunk well developed, consisting of two large lateral plates and a long narrow median element equivalent to the two diamond-shaped median bones of *Coccosteus* fused together; ventral and dorsal armour united by lateral plates, of which the anterior dorso-lateral exhibits a large articulating eminence, but has

no forwardly directed process. Pectoral arch represented by at least one pair of short and deep, curved bones, immediately in advance of the dorsal and lateral armour; pectoral appendages with a short, robust spine. [Median fins unknown.]

This genus comprises species chiefly of gigantic size, but none are represented in the Collection. The following have been described :—

Dinichthys corrugatus, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 151, pl. vii. fig. 3.—Cleveland Shale (Lower Carboniferous); Lorain Co., Ohio. [Anterior portion of mandible; Columbia College, New York.]

Dinichthys curtus, J. S. Newberry, Trans. New York Acad. Sci. vol. vii. (1888), p. 179, and *op. cit.* (1889), p. 156, pl. xlviii. fig. 3, pl. liii. figs. 1–3.—Erie and Cleveland Shales; Ohio and Pennsylvania. [Head, &c.; Columbia College.]

Dinichthys ? eifelensis, E. Kayser, Zeitschr. deutsch. geol. Ges. vol. xxxii. (1880), p. 818.—Devonian ("Crinoidenschicht"); Gerolstein, Eifel. [Mandibular ramus and fragmentary plates; Geol. Surv. Museum, Berlin.]

Dinichthys intermedius, J. S. Newberry, *op. cit.* (1889) p. 152, pl. x. figs. 1, 2, pl. xlvii. figs. 1–4, pls. li., lii.—Cleveland Shale; Cuyahoga and Lorain Cos., Ohio. [Head, &c.; Columbia College.]

Dinichthys gouldi, J. S. Newberry, *op. cit.* p. 150, pl. ix.—Cleveland Shale; Rocky River, near Berea, Ohio. [Head, &c.; Columbia College.]

Dinichthys hertzeri, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 316, pls. xxx., xxxi., and *op. cit.* (1889), p. 64, pl. xxxii. fig. 2.—Huron Shale (Upper Devonian); Delaware, Ohio. [The type species, founded upon the head, with jaws, &c.; Columbia College (in part).]

Dinichthys minor, J. S. Newberry, Ann. New York Acad. Sci. vol. i. (1878), p. 191, and *op. cit.* (1889), p. 149, pl. viii. figs. 1–8.—Cleveland Shale, Lorain Co., Ohio. [Dorsal shield, median occipital, and portions of jaws; Columbia College.]

Dinichthys newberryi, J. M. Clarke, Bull. U.S. Geol. Surv. no. 16 (1885), p. 17, pl. i. fig. 1.—Hamilton Shale (Upper Devonian); W. New York. [Mandibular ramus; National Museum, Washington.]

Dinichthys ? precursor, J. S. Newberry, Palæoz. Fishes N. America (1889), p. 51, pl. xli.—Corniferous Limestone (Lower Devonian); Sylvania, Ohio. [Median dorsal shield.]

Dinichthys ringuebergi, J. S. Newberry, *op. cit.* (1889), p. 60: *Dinichthys minor*, E. N. S. Ringueberg (*non* Newberry), Amer. Journ. Sci. [3] vol. xxvii. (1884), p. 476, woodc. figs. 1, 2.—Portage Group (Lower Carboniferous); Sturgeon Point, New York. [Median dorsal shield.]

Dinichthys terrelli, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 322, and *ibid.* vol. ii. pt. ii. (1875), p. 27, charts v., vi., and Palæoz. Fishes N. America (1889), pl. iv. figs. 1, 2: *D. hertzeri*, J. S. Newberry (*errore*), Rep. Geol. Surv. Ohio, vol. i. pt. ii. pls. xxxii.–xxxiv.—Huron Shale; Lorain Co., Ohio. [Head, with jaws, &c. This is the largest known species, the transverse measurement of the occipital region of the cranium being 0·95.]

(?) *Dinichthys tuberculatus*, J. S. Newberry, Trans. New York Acad. Sci. vol. vii. (1888), p. 179, and *op. cit.* (1889), p. 98, pl. xxxii. fig. 3.—Chemung Group (Upper Devonian); Warren, Pennsylvania, and Ohio. Also recorded from Psammite de Condroz, near Liége, Belgium. [Portions of tuberculated plates.]

Genus **TITANICHTHYS**, Newberry.

[Trans. New York Acad. Sci. vol. v. 1885, p. 27.]

Plates of head and trunk [except plastron, which is unknown] resembling those of *Dinichthys*, but relatively thinner. Mandibular rami without denticulations, long and slender, grooved in the anterior portion of the oral margin, as if for a horny sheath, and somewhat turned upwards at the symphysis.

The two known species of this genus attain a size even greater than those of *Dinichthys*, the cranium measuring not less than 1·25 across the occipital region. They are described as follows, but are not represented in the Collection:—

Titanichthys agassizi, J. S. Newberry, Trans. New York Acad. Sci. vol. v. (1885), p. 27, and Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 133, pl. i. figs. 1, 2, pl. ii. figs. 1, 2, pl. iv. fig. 4.—Cleveland Shale (Lower Carboniferous); Lorain Co., Ohio. [The type species. Head; Mus. Comp. Zoology, Cambridge, Mass.]

Titanichthys clarki, J. S. Newberry, Trans. New York Acad. Sci. vol. vi. (1887), p. 164, and Palæoz. Fishes N. America

(1889), p. 133, pl. ii. figs. 3, 4, pl. iii. figs. 1–5, pl. iv. fig. 3.—Cleveland Shale; Ohio. [Head, &c.; Columbia College, New York.]

Genus **MACROPETALICHTHYS**, Norwood & Owen.

[Amer. Journ. Sci. [2] vol. i. 1846, p. 371.]

Syn. *Physichthys*, H. von Meyer, Palæontogr. vol. iv. 1855, p. 80.
Agassichthys, J. S. Newberry, Bull. National Institute, 1857, p. 3.

Cranial shield much arched from side to side, superficially ornamented with stellate tubercles; sensory canals forming large tubular excavations in the bone, opening at the external surface by a continuous narrow slit. Elements of cranial shield fused together in the adult; orbits completely surrounded; parachordal cartilages ossified; [jaws unknown].

In the description of this genus by Newberry [1], the sensory canals are regarded as "double sutures," and the arrangement of the bones still remains to be determined.

There are no remains of *Macropetalichthys* in the Collection, but the following species have been distinguished:—

Macropetalichthys agassizi, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 291: *Placothorax agassizi*, H. von Meyer, Neues Jahrb. 1846, p. 596, and Palæontogr. vol. i. (1847), p. 102, pl. xii. fig. 1: *Asterolepis hoeninghausii*, L. Agassiz, Poiss. Foss. V. G. R. (1845), pp. 130, 147, pl. xxx. *a*. fig. 10: *Physichthys hoeninghausii*, H. von Meyer (in part), Palæontogr. vol. iv. (1855), p. 80, pl. xv. figs. 1–5 (*non* figs. 6–11) [2].—Devonian; Eifel, Germany.

Macropetalichthys pruemiensis, E. Kayser, Zeitschr. deutsch. geol. Ges. vol. xxxii. (1880), p. 678 (name only).—Lower Devonian; Prüm, Eifel. [Fragment; Geol. Surv. Museum, Berlin.]

Macropetalichthys sullivanti, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 294, pl. xxiv., pl. xxv. fig. 1, and Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi.

[1] J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 290, and Palæoz. Fishes N. America (1889), p. 41.

[2] The specimens described by Meyer are preserved in the Museum of Comparative Zoology, Cambridge, Mass., where the present writer has examined them. Only the original of figs. 1–5 pertains to *Macropetalichthys*; the plate shown in fig. 7 being apparently an anterior median dorsal of *Pterichthys rhenanus*; while the original of fig. 9 is a Chimæroid tooth, and figs. 6, 8, and 10 are not readily determinable.

1889), p. 44: *Macropetalichthys rapheidolabis*, Norwood and Owen, Amer. Journ. Sci. [2] vol. i. (1846), p. 371: *Agassichthys sullivanti* and *A. manni*, J. S. Newberry, Bull. National Institute, 1857, p. 3: *Macropetalichthys manni*, J. S. Newberry, Amer. Journ. Sci. [2] vol. xxiv. (1862), p. 75.—Corniferous Limestone (Lower Devonian); Ohio, [The type species; E. D. Cope Collection, Philadelphia.]

Genus **HOMOSTEUS,** Asmuss.

[Das vollkommenste Hautskelet der bisher bekannten Thierreihe (Inaug. Dissert. Dorpat, 1856), p. 8 (*Homostius*).]

Syn. *Asterolepis*, L. Agassiz (*non* Eichwald), Poiss. Foss. V. G. R. 1845, p. 89 (in part); H. Miller (*non* Eichwald), Footprints of the Creator, 1849, p. 70 (in part).

Head and trunk broad, the dorsal aspect flattened; scutes ornamented with stellate tubercles; caudal region destitute of armour. Occipital elements of cranial shield constituting more than half of its length; orbits completely surrounded, the preorbital and postorbital plates forming the narrow outer bar; a distinct small median bone over the pineal region, not perforated; mandibular rami suturally united at the symphysis, apparently toothless. A single broad median dorsal shield upon the trunk, with an inner longitudinal keel, and obtuse posteriorly; two dorso-lateral plates on each side, the anterior relatively large, with a well-developed, forwardly-directed, antero-external process, but no prominent condyle for articulation with the external occipitals. [Ventral armour unknown.]

The known species of this genus attain a large size, the width of the body-shield in *H. milleri* being not less than 0·28.

Homosteus formosissimus, Asmuss.

1844. *Asterolepis*, L. Agassiz (*non* Eichwald), Poiss. Foss. V. G. R. p. 96, pl. xxxii. figs. 2, 9, 10.

1856. *Homostius formosissimus*, H. Asmuss, Das vollkommenste Hautskelet der bisher bekannten Thierreihe, p. 35.

1856. *Homostius cataphractus*, H. Asmuss, *ibid.* p. 36. [Median occipital; University Museum, Dorpat.]

1856. *Homostius latus*, H. Asmuss, *ibid.* p. 36. [Ditto.]

1856. *Homostius ponderosus*, H. Asmuss, *ibid.* p. 37. [Lateral occipital; University Museum, Dorpat.]

1856. *Homostius anceps*, H. Asmuss, *ibid.* p. 39. [Bones; University Museum, Dorpat.]

1857. *Homostius*, C. H. Pander, Placoderm. devon. Syst. p. 74, pl. viii. figs. 2, 6, 7.

1860. *Homostius latus*, E. von Eichwald, Leth. Rossica, vol. i. p. 1519, pl. lvi. fig. 2.

Type. Portion of median dorsal plate; University Museum, Dorpat.

The type species, known only from separately discovered bones Median dorsal plate broader behind than in front, the posterior margin only slightly convex; forwardly directed process of anterior dorso-lateral plate slender and pointed.

Form. & Loc. Lower Devonian: Livonia, and near Pawlowsk, Government of St. Petersburg.

The following are plaster casts of the original bones from Livonia in the University of Dorpat, and were presented by Sir Roderick I. Murchison, K.C.B., about 1846.

15142 a. The type specimen, being the middle and right lateral portions of the median dorsal plate, wanting all margins except the posterior; described by Asmuss (*op. cit.* p. 35, no. 5) as "scutum dorsale anterius," and the posterior border regarded as anterior.

15142 b. Imperfect left anterior dorso-lateral (Pander, fig. 2^{11}), described by Asmuss (p. 36, no. 35) as right "adminiculum laterale" of *H. formosissimus*.

15142 c. Left postorbital (Pander, fig. 2^{5}, Agassiz, fig. 2), described by Asmuss (p. 38, no. 36) as right "os incunneatum" of *H. latus*.

15142 d. More imperfect example of the same bone, showing the postero-lateral extension.

15142 e. Middle and right lateral portion of hinder half of median occipital, the type specimen of *H. latus*, Asmuss (p. 36, no. 6), and described as left anterior portion of the "scutum dorsale posterius."

15142 f. Middle portion of median occipital, the type specimen of *H. cataphractus*, Asmuss (p. 36, no. 7), and determined as "scutum dorsale posterius."

15142 g. Half of median occipital, and portion of adjoining left lateral occipital, probably the basis of Pander's partial restoration (fig. $2^{9, 10}$); described by Asmuss (p. 37, no. 32) as right "os multifixum" with "scutum dorsale posterius" of *H. cataphractus*.

15142 h. Outer portion of left lateral occipital, probably employed

in Pander's partial restoration (fig. 2^9); ? Asmuss, no. 31 ("os multifixum" of *H. formosissimus*), p. 37.

15142 i. Posterior portion of left lateral occipital, the type specimen of *H. ponderosus*, Asmuss (p. 37, no. 33), described as right "os multifixum."

15142 z. Two undetermined bones (Agassiz, pl. xxxii. figs. 9, 10); the type specimens of *H. anceps*, Asmuss (p. 39, no. 28).

Homosteus milleri, Traquair.

1849. "*Asterolepis* of Stromness," H. Miller (non *Asterolepis*, Eichwald), Footprints of the Creator, p. 70, woodc. figs. 24, 27–29, 36, 37, 39–41 (? figs. 34, 35, 38, 44, *non* figs. 25, 26, 30–33, 42).
1854. *Asterolepis asmusii*, J. Morris (*non* Agassiz), Catal. Brit. Foss. 2nd ed. p. 318.
1857. *Homostius*, C. H. Pander, Placoderm. devon. Syst. p. 74, pl. viii. figs. 3 *a–c*.
1860. *Homostius*, sp. nov., E. von Eichwald, Leth. Rossica, vol. i. p. 1520.
1869. *Asterolepis*, J. Miller, Geol. Mag. vol. vi. p. 384.
1888. *Homosteus milleri*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 511.
1889. *Homosteus milleri*, R. H. Traquair, *ibid.* vol. vi. p. 1, pl. i. fig. 1.

Type. Cranial shield; Edinburgh Museum.

A species sometimes equalling *H. latus* in size. Median occipital tapering forwards, its anterior border less than half as wide as the posterior; external occipital twice as long as its maximum breadth. Median dorsal plate narrower behind than in front, the posterior margin obtusely angulated in the middle; ornamented portion of anterior dorso-lateral twice as long as broad, and the forwardly-directed process somewhat spatulate; posterior dorso-lateral relatively very small, triangular in form, with the hinder apex deflected inwards.

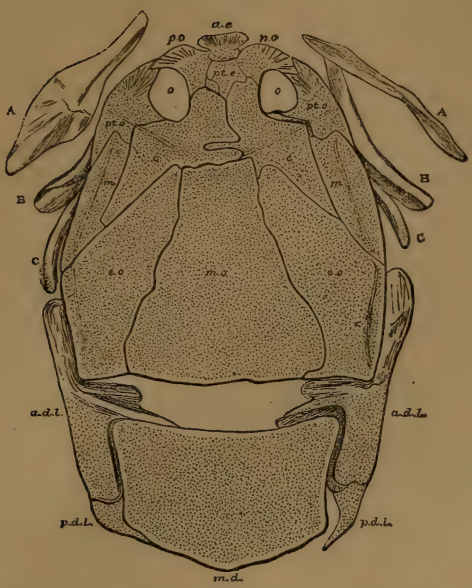
Form. & Loc. Lower Old Red Sandstone: Caithness and Orkney.

P. 5539. Plaster cast of the head and trunk, showing the boundaries and arrangement of the dorsal plates, and some of the displaced jaw-bones, &c.; Thurso. The original specimen is preserved in the Museum of Science and Art, Edinburgh, and is described and figured by Traquair, *loc. cit.* 1889. The figure is reproduced in the accompanying woodcut (fig. 46), and explained by the lettering.

Presented by the Lords of the Committee of Council on Education, 1888.

P. 5540. Plaster cast of a similar but more imperfect specimen, with displaced median dorsal plate; Thurso. The original is also preserved in the Museum of Science and Art, Edinburgh. *Presented by the Lords of the Committee of Council on Education*, 1888.

Fig. 46.



Homosteus milleri, Traq.—Outline of cranial and dorsal shield, by R. H. Traquair, one-sixth nat. size. A, B, C, undetermined bones; *a.d.l.*, anterior dorso-lateral; *a.e.*, ethmoid; *c.*, central; *e.o.*, external occipital; *m.*, marginal; *m.d.*, median dorsal; *m.o.*, median occipital; *o.*, orbit; *p.d.l.*, posterior dorso-lateral; *p.o.*, preorbital; *pt.e.*, pineal; *pt.o.*, postorbital.

P. 698. Series of seven plaster casts of specimens in the Hugh Miller Collection, Edinburgh Museum, five being figured by Miller, *op. cit.* figs. 27, 28, 35, 39; Orkney. *Egerton Coll.*

P. 699. Imperfect median dorsal plate measuring, in its broken condition, 0·28 across; Orkney. *Egerton Coll.*

P. 3227. Portion of dermal plate, showing stellate tubercular ornament; Orkney. *Enniskillen Coll.*

x 2

Genus **HETEROSTEUS,** Asmuss.

[Das vollkommenste Hautskelet der bisher bekannten Thierreihe (Inaug. Dissert. Dorpat, 1856), p. 7 (*Heterostius*).]

Syn. *Ichthyosauroides*, S. Kutorga, Zweiter Beitr. Geogn. u. Paläont. Dorpat's, 1837, p. 35 (inappropriate).
Chelonichthys, L. Agassiz, Poiss. Foss. vol. i. 1844, p. xxxiii. (name only, in part).
Asterolepis, L. Agassiz (*non* Eichwald), Poiss. Foss. V. G. R. 1845, p. 89 (in part).

A genus of enormous size, closely allied to *Homosteus*, but known only from detached dermal bones. Head and trunk broad, the dorsal aspect flattened; scutes ornamented with large stellate tubercles, and those of the upper surface of the head also marked with deep sensory furrows. A single broad median dorsal shield upon the trunk, with an inner longitudinal keel, and more or less acutely pointed posteriorly; the anterior dorso-lateral plate on each side with a very large, forwardly-directed, antero-external process, and a prominent condyle for articulation with the external occipital.

Heterosteus asmussi (Agassiz).

1837. *Trionyx spinosus*, S. Kutorga, Zweiter Beitr. Geogn. u. Paläont. Dorpat's, p. 9, pl. i.
1837. Humerus *Trionychis*, S. Kutorga, *ibid.* p. 17, pl. viii. fig. 1.
(?) 1837. *Trionyx miliaris*, S. Kutorga, *ibid.* p. 16, pl. vii. fig. 4.
1844. *Chelonichthys asmusii*, L. Agassiz, Poiss. Foss. vol. i. p. xxxiii. (name only).
1845. *Asterolepis asmusii*, L. Agassiz, Poiss. Foss. V. G. R. pp. 92, 146, pl. xxx. fig. 1, pl. xxx. *a*. fig. 11.
1845. *Asterolepis*, L. Agassiz (*non* Eichwald), *ibid.* p. 94, pl. xxxii. figs. 7, 11–13, 15–19.
1856. *Heterostius hueckii*, H. Asmuss, Das vollkommenste Hautskelet der bisher bekannten Thierreihe, p. 28. [Median dorsal plate; University Museum, Dorpat.]
1856. *Heterostius gracilior*, H. Asmuss, *ibid.* p. 28. [Ditto.]
1856. *Heterostius convexus*, H. Asmuss, *ibid.* p. 28. [Ditto.]
1856. *Heterostius eurynotus*, H. Asmuss, *ibid.* p. 28. [Ditto.]
1856. *Heterostius ingens*, H. Asmuss, *ibid.* p. 29. [Median occipital; University Museum, Dorpat.]
1856. *Heterostius secundarius*, H. Asmuss, *ibid.* p. 30. [Anterior dorso-lateral; University Museum, Dorpat.]
1856. *Heterostius initialis*, H. Asmuss, *ibid.* p. 31. [Ditto.]
1857. *Heterostius*, C. H. Pander, Placoderm. devon. Syst. p. 82, pl. viii. fig. 1.

1860. *Heterostius eurynotus*, E. von Eichwald, Leth. Rossica, vol. i. p. 1524.

Type. Fragment of dermal armour.

The type species, of very large size, known only from separately-discovered bones. Forwardly-directed process of anterior dorso-lateral more than twice as long as the remainder of the bone. Ornamentation sparse.

Form. & Loc. Lower Devonian: Livonia.

The following are plaster casts of the original bones from Livonia in the University of Dorpat, described by Asmuss, and were presented by Sir Roderick I. Murchison, K.C.B., about 1846 :—

15142 j. Imperfect median dorsal plate, shown from the inner aspect and the posterior margin placed uppermost by Agassiz (*op. cit.* pl. xxxii. fig. 13); the type specimen of *H. hueckii*, Asmuss (*op. cit.* p. 28, no. 1), described as "scutum dorsale anterius."

15142 k. Fragment of middle portion of a similar plate (Agassiz, pl. xxxii. fig. 8); the type specimen of *H. gracilior*, Asmuss (p. 28, no. 2).

15142 l. Anterior portion of inner keel of median dorsal shield; the type specimen of *H. convexus*, Asmuss (p. 28, no. 3).

15142 m. Fragment of median dorsal shield (Agassiz, pl. xxxii. figs. 11, 12); the type specimen of *H. eurynotus*, Asmuss (p. 28, no. 4).

15142 n. Imperfect right anterior dorso-lateral (Agassiz, pl. xxxii. fig. 19); described by Asmuss (p. 30, no. 19) as "adminiculum laterale" of *H. eurynotus*.

15142 o. Similar bone, less imperfect, but scarcely more than half as large as the latter (Agassiz, pl. xxxii. fig. 18, Pander, pl. viii. fig. 1″); described by Asmuss (p. 30, no. 18) as *H. convexus*.

15142 p. Fragment of process of similar bone; assigned to *H. ingens* by Asmuss (p. 30, no. 20).

15142 q. Expanded portion of a similar bone, left side; the type specimen of *H. secundarius*, Asmuss (p. 30, no. 22).

15142 r. Similar specimen, showing overlapping fragments posteriorly; the type specimen of *H. initialis*, Asmuss (p. 31, no. 25).

15142 s. Imperfect median occipital, shown from the inner aspect and the posterior margin placed uppermost by Agassiz (pl. xxxii. fig. 7), and figured by Pander (*op. cit.* pl. viii. fig. 1^{10}); the type specimen of *H. ingens*, Asmuss (p. 29, no. 9), described as "scutum dorsale posterius."

15142 t. Right lateral occipital ("mastoid" or marginal, Pander, pl. viii. fig. 1^{9}), figured by Agassiz (pl. xxxii. figs. 15, 16), the glenoid extremity being placed uppermost; described by Asmuss (p. 32, no. 16) as "os multifixum" of *H. eurynotus*.

15142 u. Portion of similar bone; assigned by Asmuss (p. 32, no. 15) to *H. gracilior*.

15142 v. Bone figured by Agassiz (pl. xxxii. fig. 17) and identified by Pander (pl. viii. fig. 1^{5}) with the anterior extremity of the postorbital; described by Asmuss (p. 32, no. 38) as left "os incunneatum" of *H. convexus*.

15142 w. Portion of bone identified by Pander (pl. viii. fig. 1^{5}) with the hinder half of the postorbital; described by Asmuss (p. 32, no. 17) as upper half of left "os interjectum."

The right half of a median dorsal plate of *Heterosteus*, from Dorpat, is described by S. Kutorga[1] as the coracoid of a genus of reptiles, *Ichthyosauroides*, allied to *Ichthyosaurus*. This is regarded as the type of a distinct species of *Heterosteus*, *H. kutorgæ*, by Asmuss (*op. cit.* p. 29), and the original of the first of the undermentioned plaster casts is also assigned to it.

15142 x. Hinder middle portion of small median occipital ("scutum dorsale posterius," Asmuss, p. 29, no. 8), probably referable to young individual of *H. asmussi*; original from Dorpat.

Presented by Sir Roderick I. Murchison, K.C.B., about 1846.

15142 y. Portion of left half of a similar bone, assigned to *H. convexus* by Asmuss (p. 29, no. 10); original from Dorpat.

Presented by Sir Roderick I. Murchison, K.C.B., about 1846.

Several bones found associated with those of *Homosteus* and *Heterosteus* in the Lower Devonian of Livonia are also represented in the Collection by plaster casts, presented by Sir Roderick I. Mur-

[1] Zweiter Beitr. Geogn. u. Paläont. Dorpat's, 1837, p. 35, pls. v., vi.

chison, K.C.B., about 1846, and entered under the general number 15142. Five are figured by Agassiz (Poiss. Foss. V. G. R. pl. xxxii. figs. 3–6, 14), and a few are regarded by the same author (*ibid.* p. 94) as referable to *Asterolepis minor*. Two are of the form named *Trionyx sulcatus*, S. Kutorga, Beitr. Geogn. u. Paläont. Dorpat's, ii. (1837), p. 13, pl. ii. figs. 1–4, and resemble the specimen from the Lower Old Red Sandstone of Thurso determined as "Shoulder (*i. e.* coracoid?) plate of *Asterolepis*" by Hugh Miller, "Footprints of Creator" (1849), p. 88, woodc. fig. 38.

A single slab of Cleveland Shale (Lower Carboniferous), discovered by Dr. William Clark in the bank of the Rocky River, below Berea, Ohio, and now in the Museum of Columbia College, New York, seems to pertain to a genus of Coccosteidæ distinct from all described above. The fish is characterized by very slender, prominently denticulated mandibular bones, a ring of four sclerotic (?) plates, and a scute-ornament of large, high, conical tubercles. It is named *Trachosteus clarki*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 167, pl. xlii. figs. 1–8.

Other large detached dermal plates, perhaps for the most part referable to this family, are also described as follows:—

Aspidichthys, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 322, with the type species, *A. clavatus*, Newberry, *ibid.* p. 323, pl. xxxv. figs. 1, 2, from the Huron Shale (Upper Devonian) of Delaware, Ohio. [Columbia College, New York.] Also *A.? ingens*, A. von Koenen, Abh. phys. Cl. k. Ges. Wiss. Göttingen, vol. xxx. (1883), p. 34, pl. iii. fig. 1, pl. iv. fig. 4, from the Upper Devonian of Martenberg, near Adorf, and Charlottenzug, near Bredelar, N. Germany [Royal Geological Museum, Göttingen]; and perhaps the so-called *Coccosteus fritschi*, Barrande (see p. 294).

Anomalichthys, A. von Koenen, Abh. phys. Cl. k. Ges. Wiss. Göttingen, vol. xxx. (1883), p. 38, with the type species, *A. scaber*, A. von Koenen, *ibid.* p. 38, pl. iii. fig. 2, from the Upper Devonian of Martenberg, near Adorf. [Royal Geological Museum, Göttingen.]

Drepanaspis, C. Schlüter, Sitzungsb. niederrhein. Ges. Bonn, 1887, p. 126, with the type species, *D. gemuendenensis*, Schlüter, *ibid.* p. 126.—Lower Devonian; Gemünden, Eifel. [Bonn University Museum.]

Glyptaspis, J. S. Newberry, Palæoz. Fishes N. America (1889), p. 157, with the type species, *G. verrucosa*, Newberry, *ibid.* p. 158, pl. xiii. figs. 1, 2, from the Cleveland Shale (Lower Carboniferous) of Ohio. [Columbia College, New York.]

Lophostracon spitzbergense, E. R. Lankester, Kongl. Svenska

Vetensk.-Akad. Handl. vol. xx. no. 9 (1884), p. 5, pl. ii. fig. 6.—Lower Devonian; Dickson Bay, Spitzbergen. [Royal State Museum, Stockholm.]

The hinder portion of the head evidently of one of the Coccosteidæ, from the Devonian of the Government of Orel, Russia, has also been described under the name of *Siphonodus panderi*, G. Fischer de Waldheim, Bull. Soc. Imp. Nat. Moscou, vol. xxv. (1852), pt. i. p. 175, pl. iii. figs. 1–3. In this specimen, the ossified parachordal cartilage is seen, with the tubular canal originally occupied by the anterior extremity of the notochord.

The singular mandibular rami, described as follows, may also pertain to this family:—

Diplognathus mirabilis, J. S. Newberry, Ann. New York Acad. Sci. vol. i. (1878), p. 188, and Trans. New York Acad. Sci. vol. v. (1885), p. 27, and Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 159, pl. xi. figs. 1–4, pl. xii. figs. 1–3.—Cleveland Shale; Lorain Co., Ohio. [Columbia College, New York.]

Family ASTEROSTEIDÆ.

An imperfectly known family, as yet incompletely definable. Nasal openings large and mesially placed, scarcely, if at all, in advance of the orbits.

Genus **ASTEROSTEUS,** Newberry.

[Rep. Geol. Surv. Ohio, vol. ii. pt. ii. 1875, p. 35.]

A genus comprising species of small size, known only by the cranial shield. Head long and narrow, flattened, having the constituent elements fused in the adult; orbits placed far forwards and forming broad notches, between which is a pair of large, oval nasal openings; a pineal foramen somewhat more posteriorly. Cranial roof ornamented with large, rounded, stellate tubercles, very irregular in size and arrangement.

This diagnosis is based upon a personal examination of the specimens in the Columbia College, New York, and the American

Museum of Natural History. A single species is described as follows, but there are no examples in the Collection:—

Asterosteus stenocephalus, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 36, pl. liv. fig. 1, and Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 45, pl. xxx. fig. 1.—Corniferous Limestone (Lower Devonian); Sandusky and Delaware, Ohio. [Cranial shield; Columbia College.]

Family PHYLLOLEPIDÆ.

An imperfectly definable family, of uncertain position, probably related to the Coccosteidæ. Dermal plates very thin, and marked by a superficial ornament of rugæ, more or less following the concentric or radiating lines of growth.

Synopsis of Genera.

Superficial rugæ concentric .... *Phyllolepis* (p. 313).
Superficial rugæ radiating ..... *Holonema* (p. 314).

Genus **PHYLLOLEPIS**, Agassiz.

[Poiss. Foss. V. G. R. 1844, p. 67.]

Dermal plates concentrically marked with more or less irregular and wavy rugæ.

These problematical fossils have hitherto only been found isolated, and are rarely met with unbroken. By most palæontologists they are associated with the Holoptychian Crossopterygii, while Fritsch has compared them with head-bones of Palæozoic Dipnoi. We venture, however, to adopt the suggestion of Newberry that the plates are truly referable to some so-called "Placoderm," though we would compare them with *Coccosteus* and its allies rather than with *Pterichthys*.

If the last-named suggestion prove correct, this genus will also include the small dermal plates from the Psammites of Condroz (Upper Devonian), Belgium, named *Pentagonolepis koninckı*, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. (1888), p. 161, pl. xi. figs. 1–8. Moreover, the form of the dermal plates cannot be cited in specific diagnoses until their arrangement and homologies have been determined.

Phyllolepis concentrica, Agassiz.

1844. *Phyllolepis concentricus*, L. Agassiz, Poiss. Foss. V. G. R. p. 67, pl. xxiv. fig. 1.
1862. *Phyllolepis concentricus*, W. Davies, Geologist, vol. v. p. 458.
1888. *Phyllolepis concentricus*, A. Fritsch, Fauna der Gaskohle, vol. ii. p. 89, woodc. fig. 169.

Type. Imperfect dermal plate; unknown.

The type species, of large size. Superficial rugæ coarse, rounded or slightly angulated, somewhat wavy, and separated by spaces two or three times their own width.

Form. & Loc. Upper Old Red Sandstone: Perthshire and Fifeshire. (?) Devonian: Meadsfoot, Torquay.

P. 3292. Specimen measuring 0·095 in its longest diameter, so far as preserved, and having one long border obtusely angulated; Dura Den, Fifeshire. The fossil must have been gently convex, but it occurs chiefly as a concave impression, from which is taken the plaster cast figured by A. Fritsch, *loc. cit.* *Enniskillen Coll.*

P. 5096. Fragment of plate; Clashbennie, Perthshire.
Presented by John Edward Lee, Esq., 1885.

Other plates of this genus have been described under the following names:—

Phyllolepis delicatula, J. S. Newberry, Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 97, pl. xix. fig. 11.—Chemung Group (Upper Devonian); Bradford Co., Pennsylvania.

Phyllolepis corneti, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. (1888), p. 157, pl. x. fig. 6.—Upper Devonian; Strud and Chèvremont, Belgium. [M. Lohest Collection, Liége.]

Phyllolepis undulata, M. Lohest, *ibid.* p. 157, pl. x. figs. 3–5, pl. xi. fig. 9.—Upper Devonian; Strud, Chèvremont, and Evieux, Belgium. [M. Lohest Collection.]

Genus **HOLONEMA,** Newberry.

[Palæoz. Fishes N. America, 1889, p. 92.]

Dermal plates marked with irregularly branching, radiating rugæ. The form of the median ventral plate of this genus (figured by

Newberry, *op. cit.* pl. xvii. fig. 2) more closely resembles that of certain species of *Coccosteus* (e. g. *C. disjectus*, p. 292) than the corresponding plate of the Asterolepidæ; and the recent description of the complete ventral shield by Claypole (Amer. Geologist, 1890, p. 255, with fig.) proves that it agrees with that of *Coccosteus* in every essential particular. The "post-dorso-median" plate of Claypole is obviously the anterior median ventral, while the "post-dorso-lateral" and "dorso-lateral" of the same author are the anterior and posterior ventro-lateral plates respectively.

There are no examples of this genus in the Collection, and only a single species has as yet been recognized, thus :—

Holonema rugosum, J. S. Newberry, *op. cit.* p. 93, pl. xvii. figs. 1–4: *Pterichthys* (?) *rugosus*, E. W. Claypole, Proc. Amer. Phil. Soc. vol. xx. (1883), p. 666, with fig.: *Pterichthys* (*Bothriolepis*) *rugosus* or *Holonema rugosum*, E. W. Claypole, Amer. Geologist, 1890, p. 257, with fig.—Chemung Group (Upper Devonian); New Jersey and N. Pennsylvania. Catskill Group (Upper Devonian); New York State. [Median ventral plate; Museum of Akron College, Ohio.]

So far as can be determined from the description and imperfect figures, the dermal plates from the Devonian of the Eifel, named *Coccosteus obtusus*, Koenen (see p. 294), exhibit much resemblance to those of *Holonema*.

Family MYLOSTOMATIDÆ.

An imperfectly known family, as yet incompletely definable. Dentition consisting of a paired series of few large, dense, triturating plates in each jaw.

Genus **MYLOSTOMA**, Newberry.

[Trans. New York Acad. Sci. vol. ii. 1883, p. 145.]

The type genus, known only by the teeth and the bones of the mandible. Principal dental plates triangular or spatulate in form, flattened or with an irregularly tumid coronal surface, which is more or less nearly parallel with the attached surface. Dentigerous bone of the lower jaw exhibiting a much-expanded oral border for the support of the teeth.

This genus is not represented in the Collection, and has only been

discovered hitherto in the Lower Carboniferous of the United States. Two species are recognized, the type specimens being preserved in the Museum of Columbia College, New York.

Mylostoma terrelli, J. S. Newberry, Trans. New York Acad. Sci. vol. ii. (1883), p. 147, and Palæoz. Fishes N. America (1889), p. 164, pl. xiv. figs. 1, 2.—Cleveland Shale; Erie Co., Ohio.

Mylostoma variabile, J. S. Newberry, *ibid.* (1883), p. 146, and *ibid.* (1889), p. 165, pl. xv. figs. 1–5, pl. xvi. figs. 1–4.—Cleveland Shale; Sheffield, Ohio. [The type species.]

Possibly in this family may also be placed the tooth from the Devonian of the Eifel, named *Typodus glaber*, H. von Meyer, Palæontogr. vol. i. (1847), p. 102, pl. xii. fig. 2.

Subclass V. TELEOSTOMI.

Skeleton more or less ossified, with well-developed membrane-bones: margin of jaw with membrane-bones above and below. Mandibular suspensorium articulated with the cranium; gill-clefts feebly separated, opening into an external cavity covered by a bony operculum. Membrane-bones of pectoral arch connected with those of the occiput. Exoskeleton, when present, consisting of true bone or delicate, superposed, calcified lamellæ. In the living forms—ovaries with numerous small ova.

Order I. CROSSOPTERYGII.

Paired fins lobate, having an endoskeletal axis, more or less fringed with dermal rays; caudal fin diphycercal or heterocercal. A pair of large jugular plates, sometimes with small lateral plates and an anterior azygous element, developed in the branchiostegal membrane between the mandibular rami. In the living forms—optic nerves not decussating, but forming a chiasma; intestine with a spiral valve.

Suborder I. *HAPLISTIA.*

Notochord more or less persistent. Axonosts and baseosts of median fins in simple regular series, much fewer in number than the dermal fin-rays.

Only one specialized family is provisionally placed here, that of the Tarrasiidæ.

Family TARRASIIDÆ.

Membrane-bones of head and opercular fold well developed. Pectoral fins obtusely lobate; tail diphycercal, with a continuous dorso-caudal fin; median fin-supports more numerous than the vertebral arches.

The pelvic fins remain unknown.

Genus **TARRASIUS,** Traquair.

[Trans. Roy. Soc. Edinb. vol. xxx. 1881, p. 61.]

Trunk elongated, laterally compressed; head small, its external bones superficially coated with ganoine. Anal fin continuous with the caudal. Caudal region enveloped in very small, thick, quadrangular, ganoid scales, which scarcely overlap but are closely arranged.

Tarrasius problematicus, Traquair.

1881. *Tarrasius problematicus*, R. H. Traquair, *loc. cit.* p. 62, pl. iv. figs. 4–6.

1890. *Tarrasius problematicus*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 494.

Type. Imperfect fishes; Geological Survey of Scotland, Edinburgh.

The type species, of small size, attaining a maximum length of about 0·06, in which the head with opercular apparatus is contained from five to six times. Scales superficially marked with a median depression.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Glencartholm, Eskdale, Dumfriesshire.

P. 4704 Two fragmentary specimens, one being in counterpart.
Purchased, 1883.

Suborder II. *RHIPIDISTIA.*

Notochord more or less persistent. Axonosts of each of the dorsal and anal fins fused into a single piece; baseosts much fewer than, and overlapped by, the dermal rays in all the median fins.

Synopsis of Families.

I. Pectoral fins acutely lobate.	
Vertical infoldings of the walls of the teeth very numerous and complex ('dendrodont'); scales cycloidal ..	Holoptychiidæ (p. 321).
II. Pectoral fins obtusely lobate.	
Vertical infoldings of the walls of the teeth comparatively few and simple; scales cycloidal	Rhizodontidæ (p. 341).
Walls of teeth only slightly infolded at the base; scales rhomboidal	Osteolepidæ (p. 367).
III. Incertæ Sedis.	
Tooth-structure simple; a dentigerous presymphysial bone; scales cycloidal	Onychodontidæ (p. 391).

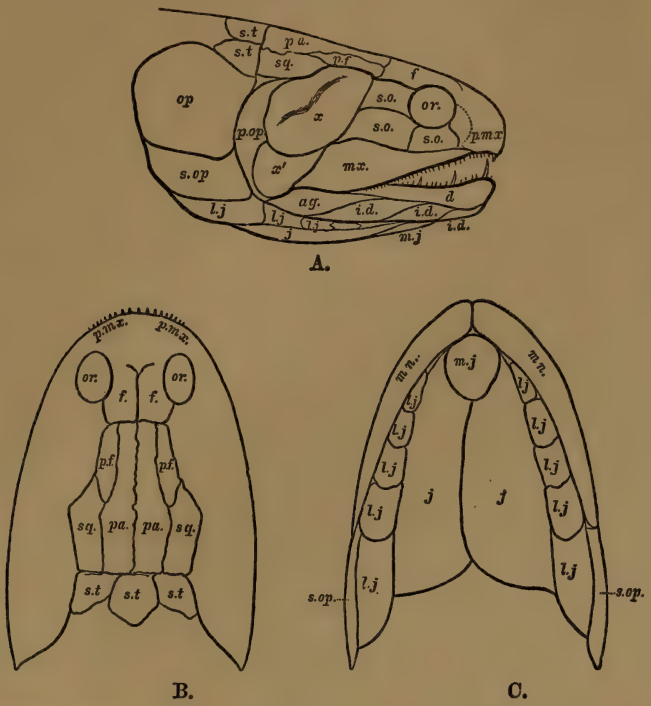
The osteology of some members of each of the three typical families of Rhipidistia is now tolerably well known, as the result especially of researches by Pander, Huxley, and Traquair. There is a remarkable uniformity in the arrangement of the bones and fins, and a brief summary of the chief structural features may be presented as follows.

The cranial cartilage is in some degree ossified, but the precise arrangement and extent of nearly all the tracts remain still unknown. It suffices to remark that in *Megalichthys* (*Ectosteorhachis*) the parachordal cartilages are ossified in the form of a pair of large, subtriangular expansions, which unite mesially and embrace the notochord in a groove, which is roofed behind but open anteriorly[1]. The whole of the cranium, however, is covered with thick dermal plates, which exhibit a definite symmetrical disposition except towards the extremity of the rostrum; and there is, similarly, a considerable development of membrane-bones on the roof of the mouth. The shield of the cranial roof is divided by a much-pronounced, transverse suture into a parietal and frontal moiety, the latter being usually the smaller, and excavated on each side to form the upper border of the orbit. The parietal portion of the shield consists chiefly of a long, narrow pair of parietal bones,

1 E. D. Cope, Proc. Amer. Phil. Soc. vol. xx. (1883), p. 628.

extending its whole length, flanked by a pair of squamosal elements in the hinder half, and usually also by a pair of postfeontal plates in front of these. The posterior half of the frontal shield is formed by the frontal bones, which extend from side to side, and are sometimes fused together in the middle line, with or without a median (pineal) foramen; the anterior extremity of the shield consists of

Fig. 47.



Rhizodopsis sauroides (Williamson).—Outlines of head and opercular apparatus, after Traquair. A. Side view. B. Upper aspect. C. Inferior aspect. *ag*, angular; *d*, dentary; *f*, frontal; *i.d*, infradentary; *j*, principal jugular; *l.j*, lateral jugular; *m.j*, median jugular; *mx*, maxilla; *mn*, mandible; *op*, operculum; *or*, orbit; *p.f*, postfrontal; *p.mx*, premaxilla; *p.op*, preoperculum; *pa*, parietal; *s.o*, suborbital; *s.op*, suboperculum; *s.t*, supratemporal; *sq*, squamosal; *x*, cheek-plate; *x'*, (?) jugal.

the dentigerous premaxillæ, usually fused together, and also more or less in connection with the irregular small dermal plates which intervene between them and the frontals. The cheek is entirely covered with loose plates, of which the suborbitals behind and

below the eye are conspicuous; the dentigerous maxilla bounds these below, and exhibits a small (apparently jugal) plate behind its posterior expansion. The latter element extends far backwards, and immediately above it is a very large cheek-plate covering the whole of the space between the posterior suborbitals, the cranial roof, and the preoperculum. On the roof of the mouth there is a well-ossified parasphenoid, meeting in front a pair of vomers, each of which bears a powerful tooth; and there are some traces of an inward palatal extension both of the maxillæ and premaxillæ.

The mandible is very complex and seems to possess a distinctly ossified articular element. The dentary bone is relatively deep and thick at the symphysis, tapering backwards, and bears a series of small teeth, with a single large laniary in front. The lower border is bounded by a series of three or four, plate-like, lenticular bones, of which the hindermost seems to correspond to the angular, while the others are conveniently termed infradentaries. A thin splenial lamina forms the inner wall of the ramus, and between this and the dentary is arranged a series of about three or four very stout lenticular bones, each of which bears a laniary tooth.

A deep and narrow preoperculum is observed behind the cheek-plates, while the operculum and suboperculum are well developed; there is, however, no representative of an interoperculum. Below the suboperculum a long narrow plate forms the hinder element of the series of lateral jugulars on each side; and a pair of very large principal jugular plates, with or without a small anterior azygous element, occupies the whole of the space between these series.

The cranial roof is bordered behind by three small supratemporal plates, one median and a pair lateral; but there appear to be no large scales on the posterior margin of the pectoral arch. Behind this, so far as known, the squamation is always continuous; and the only enlargement of the scales is observed occasionally at the bases of the fins and in the anal region. There are rarely indications of a peg-and-socket articulation of the scales, although the inner rib is usually conspicuous in those that are rhomboidal, while, except in the Holoptychiidæ, this rib is represented by a median boss in the more deeply overlapping scales of cycloidal form. In one genus (*Megalichthys*) the scale-arrangement proves the anus to have been placed at some distance in advance of the anal fin, and not quite in the mesial line.

A lateral line arising immediately above the operculum traverses a longitudinal series of scales as far as an undetermined point on the caudal pedicle; and, at least in the Holoptychiidæ, there is another similar line arising from the jugular plates of either side. In the

Holoptychiidæ the sensory canal-system seems to form merely grooves in the exoskeleton; while in the Rhizodontidæ and Osteolepidæ it usually perforates the bones, and is especially conspicuous upon parts of the head from the series of dot-like apertures by which the closed canals open externally.

The notochord seems to have been always more or less persistent, but the cartilages of the arches are at least superficially calcified, and in the more specialized genera there occur robust, closely arranged ring-vertebræ.

The pectoral arch exhibits two well-developed pairs of membrane-bones—a large clavicle and a smaller infraclavicle, sometimes very firmly united by an upward process of the latter. A supraclavicular element has also been observed, but there is no definite information as to its precise characters. The lobe of the paired fins is supported by endoskeletal cartilage, arranged on the plan termed archipterygial by Gegenbaur; and it is interesting to note that even in the short, obtusely lobate fins, the axis is merely shortened and the parameres of one side somewhat atrophied, while those of the other side are enlarged. There is thus no dibasal or tribasal arrangement of the cartilages such as characterizes the pectoral fins of *Polypterus*.

In the median fins, the rays are always delicate and very numerous, overlapping the ends of the supporting cartilages, which are robust and comparatively few in number. The dorsal and anal fins always exhibit more or less lobation, and are supported by two series of cartilages, the proximal conveniently termed axonosts, and the distal baseosts. There is but a single, club-shaped axonost to each of the fins, the broad distal end of this element bearing about three to six elongated, rod-like baseosts, which are sometimes jointed at intervals and bifurcating. The arrangement of the supports of the caudal fin is not clearly ascertained.

Family HOLOPTYCHIIDÆ.

Body fusiform, with cycloidal, deeply-overlapping scales, more or less enamelled. Head and opercular apparatus with well-developed membrane-bones; parietals large and separate; frontals separate, not fused into a continuous plate with the adjoining elements; no parietal or frontal foramen; interoperculum absent; jugular plates comprising one large pair, flanked on either side by a lateral series. Dentary bone of mandible thin and deep, bearing a series of small teeth, and with well-developed infradentaries, much bent inwards below; an inner series of few, large, broad, shuttle-shaped bones,

each supporting a 'laniary' tooth; a pair of similar teeth on the roof of the mouth, but the marginal upper dentition feeble. Teeth conical, with a very small pulp-cavity, of which the walls exhibit

Fig. 48.

Transverse section of Holoptychian (Dendrodont) Tooth, much magnified; after Pander.

complex infoldings, appearing closely intertwined when viewed in transverse section, these producing superficial vertical flutings. Pectoral fins acutely lobate, pelvic fins acutely or obtusely lobate; two remote dorsal fins; anal fin single; caudal fin diphycercal or heterocercal.

The typical *Holoptychius* is the single genus of this family as yet definitely determined.

Genus **HOLOPTYCHIUS,** Agassiz.

[Agassiz in Murchison's Silur. Syst. 1839, p. 599 (*Holoptychus*), and Poiss. Foss. V. G. R. 1844, p. 68.]

Syn. *Dendrodus*, R. Owen, Microscopic Journal, vol. i. 1841, p. 4.
Platygnathus, L. Agassiz, Poiss. Foss. V. G. R. 1844, pp. 61, 76.
Lamnodus, L. Agassiz, *ibid.* 1845, p. 83.
(?) *Sclerolepis*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. 1844, p. 828.
(?) *Apedodus*, J. Leidy, Journ. Acad. Nat. Sci. Philad. [2] vol. iii. 1856, p. 164.
(As subgenus) *Glyptolepis*, L. Agassiz, Poiss. Foss. V. G. R. 1844, p. 62 (in part).

Body short and stout, not much laterally compressed; scales large and rounded, the exposed surface marked with large, longitudina

wrinkles, occasionally replaced by tubercles. Head depressed, the bones superficially granulated; teeth compressed, with a pair of sharp edges at least in the upper portion; anterior median jugular plate absent. Pelvic fins obtusely lobate, situated at or behind the middle of the body; first dorsal fin opposite the pelvic pair, second dorsal opposite or partly posterior to the anal; tail heterocercal, the upper lobe of the caudal fin small, the lower lobe triangular and obliquely truncated.

I. Holoptychius proper.

Holoptychius nobilissimus, Agassiz.

1835. *Gyrolepis giganteus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 175, pl. xix. fig. 13.
1839. *Holoptychus nobilissimus*, L. Agassiz, in Murchison's Silur. Syst. p. 600, pl. ii. *bis.* figs. 1, 2 (specific name *giganteus* withdrawn).
1841. *Holoptychius nobilissimus*, H. Miller, Old Red Sandst. p. 162, pl. ix. fig. 2.
1844. *Holoptychius murchisoni*, L. Agassiz, Poiss. Foss. V. G. R. p. 72, pl. xxii. fig. 2. [Scales.]
1845. *Holoptychius nobilissimus*, L. Agassiz, *ibid.* pp. 73, 140, pl. xxiii., pl. xxiv. fig. 2, (?) pl. xxxi. *a.* fig. 26.
1855. *Holoptychius nobilissimus* ('? amend to *noblei*'), F. M'Coy, Brit. Palæoz. Foss. p. 595.
1860. *Holoptychius nobilissimus*, E. von Eichwald, Leth. Rossica, vol. i. p. 1572.
1888. *Holoptychius nobilissimus*, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. pp. 127, 139.
1888. *Holoptychius dewalquei*, M. Lohest, *ibid.* p. 134, pl. i. fig. 5, pl. ii. figs. 1–4, pl. iii. figs. 1, 3, 5, 6, pl. v. figs. 1–3. [Scales; M. Lohest Collection, Liége.]
1890. *Holoptychius nobilissimus*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 97.
1890. *Holoptychius nobilissimus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 388.

Type. Fish wanting caudal extremity, ventral aspect; British Museum.

The type species, of very large size. Head and opercular apparatus occupying about one-fifth of the total length. Scales externally ornamented with numerous large branching ridges, often interrupted and partly tubercular on the ventral aspect of the abdomen, continuous and more delicate on the caudal pedicle; the superficial ridges rarely alternating with, and continued by, series of small tuberculations at the anterior edge of the exposed area of the scale.

Form. & Loc. Upper Old Red Sandstone: Perthshire, Fifeshire, and Roxburghshire. Upper Devonian: Belgium and N.W. Russia.

P. 6258. Type specimen described and figured by Agassiz; Clashbennie, Perthshire. The fossil exhibits the ventral aspect and displays, in addition to the features noticed by Agassiz, a considerable portion of the large, acutely-lobate pectoral fin of the right side: the obtuse lobation of the pelvic pair is also very distinct. The best figure of a typical scale is given in Murchison's Silur. Syst. pl. ii. *bis.* fig. 2. *Purchased from Rev. James Noble, about* 1840.

11531. Impression of fragments of head-bone and scales; (?) Clashbennie. *Mantell Coll.*

P. 3283. Fragments of bones and scales of a large individual; Clashbennie. *Enniskillen Coll.*

P. 701. Fragment of bone and scales; Clashbennie. *Egerton Coll.*

47725. Associated fragments of very large scales; Clashbennie. *Presented by Dr. Lauder Lindsay*, 1876.

50007. Group of imperfect large scales; Clashbennie. The impression of one scale shows the anterior tuberculations described as characteristic of *H. dewalquei*; Clashbennie. *Trevelyan Bequest.*

P. 6014. Group of very large scales, one measuring 0·07 from side to side, and another exhibiting the anterior tuberculations described as characteristic of *H. dewalquei*; Clashbennie. *Purchased*, 1889.

47724. Two imperfect scales; Maxton, Roxburghshire. *Presented by Dr. Lauder Lindsay*, 1876.

50008. Small scale, showing anterior tuberculations; Black Hill, near Melrose. *Trevelyan Bequest.*

19809 a. Fragments of scales probably of this species; "Valdai Hills," Russia. *Purchased*, 1845.

43452. Fragments of similar scales in similar matrix, associated with imperfect plates of *Bothriolepis ornata*; Prikscha, Govt. of Novgorod. *Presented by Kenneth Murchison, Esq.*, 1872.

P. 711. Slab of sandstone with numerous fragments of fishes, including a well-preserved scale apparently of this species; Russia. *Egerton Coll.*

Holoptychius giganteus, Agassiz.

1839. *Holoptychius*, R. I. Murchison, Silur. Syst. p. 600, pl. ii. *bis.* fig. 3.
1845. *Holoptychius giganteus*, L. Agassiz, Poiss. Foss. V. G. R. pp. 73, 140, pl. xxiv. figs. 3–10.
1848. *Holoptychius princeps*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 310. [Scale; Woodwardian Museum, Cambridge.]
1854. *Holoptychius giganteus*, R. I. Murchison, Siluria, pl. xxxvi. fig. 11.
1855. *Holoptychius giganteus*, F. M'Coy, Brit. Palæoz. Foss. p. 594.
1855. *Holoptychius princeps*, F. M'Coy, *ibid.* p. 595.
1888. *Holoptychius giganteus*, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. p. 146, pl. vi. figs. 2, 3, pl. vii. figs. 5, 6.
(?) 1889. *Holoptychius giganteus* ?, J. S. Newberry, Palæoz. Fishes N. America, p. 101, pl. xix. figs. 15, 16.
1890. *Holoptychius giganteus*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 96.

Type. Detached scales.

A species of very large size, known only by detached scales. Scales of abdominal region externally ornamented with close, thick, irregularly tortuous, longitudinal ridges, often branching and interrupted, more or less replaced posteriorly by rounded tubercles; caudal scales resembling those of *H. nobilissimus*.

The variety of scale named *H. princeps* by M'Coy is very rare, and may be regarded as exhibiting merely an extreme modification of the ornament just described.

The teeth of this species are probably described as *Dendrodus biporcatus* (p. 338).

Form. & Loc. Upper Old Red Sandstone: Elgin and Nairn. Upper Devonian: Belgium and N.W. Russia. (?) Catskill Group: Pennsylvania.

28869. Small (? caudal) scale; Scat Craig, near Elgin.
Purchased, 1854.

35992–93. About ten imperfect scales; Scat Craig.
Purchased, 1861.

P. 702. Six scales; Scat Craig. *Egerton Coll.*

P. 5094. Five imperfect scales; Scat Craig.
Presented by John Edward Lee, Esq., 1885.

28868. Impressions of seven scales, one small example ornamented as "*H. princeps*" and traversed by a sensory canal; Alves, near Elgin. *Purchased*, 1854.

38720. Impression of medium-sized scale; near Nairn.
Purchased, 1864.

P. 4732. Three imperfect scales, one being almost completely tuberculated, and another exhibiting only tortuous, branching, anastomosing ridges; River Ssjass, Govt. of St. Petersburg. *Purchased*, 1884

Holoptychius americanus, Leidy.

1843. *Holoptychus nobilissimus*, J. Hall (*non* Agassiz), Geol. New York, pt. iv. p. 281, woodc. fig. 130, no. 2.
1856. *Holoptychius americanus*, J. Leidy, Journ. Acad. Nat. Sci. Philad. [2] vol. iii. p. 165, pl. xvi. figs. 9, 10, pl. xvii. figs. 1–3 (*non* fig. 4).
1889. *Holoptychius americanus*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi.), p. 113, pl. xix. figs. 12, 13.

Type. Detached scales; Museum of the Academy of Natural Sciences, Philadelphia.

A large species, known only by detached scales and fragments of head-bones. Scales of abdominal region externally ornamented with thick, irregularly tortuous, longitudinal ridges, more or less interrupted and branching.

Form. & Loc. Catskill Group (Upper Devonian): Pennsylvania, U.S.A.

P. 5084. Three fragments of rock with imperfect scales; Blossburg.
Presented by John Edward Lee, Esq., 1885.

Holoptychius halli, Newberry.

1889. *Holoptychius hallii*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi.), p. 114, pl. xx. fig. 10.

Type. Imperfect trunk; New York State Museum, Albany.

Form and proportions of trunk as in the type species, but the fins apparently exhibiting a relatively greater breadth. Scales externally ornamented by broad, flattened, striated longitudinal ridges, more or less parallel, but sometimes radiating and anastomosing; no tuberculations.

Form. & Loc. Catskill Group (Upper Devonian): Delhi, New York State.

Not represented in the Collection.

Holoptychius flemingi, Agassiz.

[Plate XI. figs. 1 *a–d.*]

1844. *Holoptychius flemingii*, L. Agassiz, Poiss. Foss. V. G. R. p. 71, pl. xxii. fig. 1 (*non* p. 140, pl. xxxi. *a*. fig. 25).
1844. *Holoptychius andersoni*, L. Agassiz, *ibid.* p. 72, pl. xxii. fig. 3. [British Museum.]
1844. *Platygnathus jamesoni*, L. Agassiz, *ibid.* pp. 61, 77, pl. xxv. [Tail; British Museum.]
1855. *Holoptychius andersoni*, F. M'Coy, Brit. Palæoz. Foss. p. 594.
1859. *Holoptychius andersoni* and *H. flemingii*, J. Anderson, Dura Den, p. 57, pl. i. fig. 3, pl. vii., pl. viii. figs. 1, 2.
1859. *Platygnathus jamesoni*, J. Anderson, *ibid.* p. 56, pl. i. fig. 2.
1863. *Holoptychius flemingii*, R. Walker, Ann. Mag. Nat. Hist. [3] vol. xi. p. 73, pl. ii. (lettered *Glyptolepis*), woodc. figs. 1–4.
1863. *Glyptolepis flemingii*, H. Mitchell, Geologist, vol. vi. p. 43.
1863. *Glyptolepis flemingii*, J. Powrie, Geologist, vol. vi. p. 96.
1861. *Glyptopomus*, T. H. Huxley (*errore*), Figs. and Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 4, woodc. fig. 4.
1866. *Glyptopomus*, T. H. Huxley (*errore*), *ibid.* dec. xii. pl. i. fig. 2.
1888. *Holoptychius flemingii*, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. p. 143, pl. iii. figs. 2, 4, pl. vi. fig. 1.
1888. *Holoptychius flemingii*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 513.
1890. *Holoptychius flemingi*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 96.
1890. *Holoptychius flemingii*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 388.

Type. Group of scales.

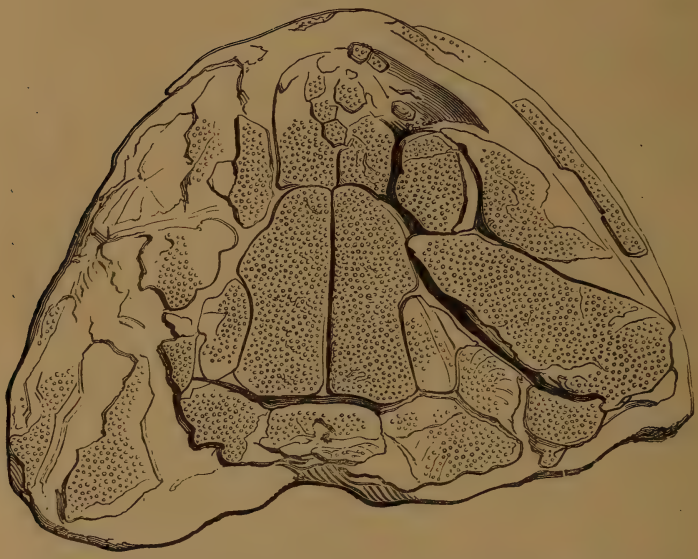
A species somewhat smaller than the type. Head and opercular apparatus occupying nearly one-fifth of the total length; first dorsal fin relatively small; second dorsal fin partly opposed to the space between the anal and the caudal. Scales externally ornamented with well-spaced delicate antero-posterior ridges, often bifurcating and sometimes anastomosing anteriorly; the ridges not interrupted, except rarely upon the ventral aspect of the abdominal region, but often continued upon the overlapped portion of the scale by short, delicate, radiating lines of inconspicuous tubercles.

Form. & Loc. Upper Old Red Sandstone: Dura Den, Fifeshire. Upper Devonian: Chèvremont and Strud, Belgium.

26117 b. Skull, mandible, and portion of the branchiostegal apparatus, ascribed to *Glyptopomus* by Huxley, *loc. cit.*; Dura Den. The woodcut, exhibiting the upper aspect one-half the natural size, is reproduced in the accompanying fig. 49. Posteriorly is a broken median element

flanked on either side by a large bone, this series being supratemporal according to Traquair's nomenclature (p. 319). A pair of large parietals occurs, with a small squamosal on each side adjoining its hinder half; and the frontals are relatively small, separated by suture, and meeting some polygonal bones in front, but exhibiting no mesial foramen. The bones apparently to be regarded as postfrontals are larger than the frontals and squamosals, and are separated from the latter by the articulation of a large cheek-plate with the parietals. On the lower aspect the right mandibular ramus exhibits infradentary bones;

Fig. 49.



Holoptychius flemingi, Ag.—Dorsal aspect of head, one-half nat. size. [No. 26117 *b*.]

a slender median, internal bone seems to belong to the hyoid apparatus; and, in addition to portions of the principal jugular plates, a lateral series of jugulars is well preserved on half of the right side. *Purchased*, 1851.

37301. Imperfect head and greater portion of trunk of an equally large fish; Dura Den. *Purchased*, 1863.

26120 a. Portion of trunk of a somewhat smaller fish, displaying the scales of the ventral aspect; Dura Den. Four of these scales are shown, of the natural size, in Pl. XI. figs. 1 *a–d*, the first two being taken from the abdominal region, the third and fourth from the caudal region. The two latter, it will be observed, are more delicate than the former, and exhibit the anterior radiating rows of tubercles usually regarded as characteristic of '*Glyptolepis*.'

Purchased, 1851.

26120 b. Slab with remains of about nine individuals, smaller than the foregoing; Dura Den. The fins are almost entirely wanting, and there are only fragments of the head and branchiostegal apparatus; but the scales are well preserved and sometimes, in the anterior abdominal region, exhibit the partial subdivision of the superficial ridges.

Purchased, 1851.

26120 c. Group of typical scales and fragments; Dura Den.

Purchased, 1851.

P. 2077–a. Imperfect fish showing portions of head and trunk, and a small slab with remains of about four individuals; Dura Den. *Egerton Coll.*

P. 3277–8. Two small slabs with imperfect remains of individuals showing the ventral aspect, associated with fragments of *Phaneropleuron*; Dura Den. The first specimen exhibits the pair of jugular plates, well preserved but accompanied by no anterior median plate. *Enniskillen Coll.*

P. 3280–1. Two slabs, the first with remains of three individuals of moderate size, the second exhibiting portions of several small fishes with fragments of fins; Dura Den.

Enniskillen Coll.

P. 3282. Imperfect fish of moderate size, exhibiting portions of the head, left pectoral fin, and the ventral scales; Dura Den.

Enniskillen Coll.

26119. Type specimen of *Holoptychius andersoni*, Agassiz, doubtless to be regarded as a young individual of *H. flemingi*; Dura Den. The fossil is completely detached from the matrix and much crushed from above downwards. The dorsal aspect, figured by Agassiz, exhibits several of the bones of the head arranged as in No. 26117 *b*; but most of the sutures are omitted in Dinkel's drawing. The

trunk affords evidence of two "lateral lines" on each side, the upper arising near the superior border of the operculum, and the lower near the inferior extremity of the clavicular plate. *Purchased*, 1851.

24839. Three imperfect young individuals, laterally compressed, associated upon one small slab; Dura Den. The head and clavicular plate are in each case preserved, but the extremity of the tail is wanting and all the scales and bones are much abraded. So far as preserved, the bones of the head and opercular apparatus agree with those of No. 26117 *b*, and a marginal series of small conical teeth is seen in the jaws. One pelvic fin is shown, apparently displaying a trace of the lobation; the first dorsal occurs directly opposite to this; and the large second dorsal seems to arise somewhat behind the origin of the equally large anal. *Purchased*, 1850.

24839 a. Several fragments of small individuals; Dura Den. *Purchased*, 1850.

26122. Type specimen of *Platygnathus jamesoni*, Agassiz, being, as pointed out by Traquair (*loc. cit.* 1888), the caudal extremity of a species of *Holoptychius*, and almost certainly referable to *H. flemingi*; Dura Den. By Agassiz the second dorsal fin is described as the anal, while the true anal and the inferior lobe of the caudal are regarded as two dorsals or perhaps one large dorsal accidentally divided. *Purchased*, 1851.

(Other remains of this species are associated with *Phaneropleuron andersoni*, and catalogued on p. 247.)

Scales of undetermined species of *Holoptychius* have been recorded from the Old Red Sandstone of England[1], and the following is a similar specimen:—

P. 5327. Imperfect impression of small scale, in conglomerate; Tortworth, Gloucestershire. *Presented by the Earl of Ducie*, 1887.

[1] R. I. Murchison, Silur. Syst. (1839), pp. 175, 601 (from Crickhowell); W. H. Baily, Rep. Brit. Assoc. 1864 (1865), Trans. Sect., p. 49, and Geol. Mag. vol. i. (1864), p. 293. The so-called scales of *Holoptychius* from Devonshire described by J. Phillips (Palæoz. Foss. Cornwall, Devon, &c., 1841, p. 133, pl. lvii. figs. 256, 257) do not pertain to this genus.

Other detached scales, of which there are no examples in the Collection, have also been named as follows:—

Holoptychius granulatus, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 100, pl. xx. fig. 9.—Chemung Group; N. Pennsylvania.

Holoptychius inflexus, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. (1888), p. 141, pl. iv. figs. 1–7, pl. v. fig. 4.—Upper Devonian; Belgium. [M. Lohest Collection.]

Holoptychius (?) *pustulosus*, J. S. Newberry, *op. cit.* p. 100, pl. xx. fig. 11.—Chemung Group; Warren, Pennsylvania.

Holoptychius (?) *radiatus*, J. S. Newberry, *ibid.* p. 115, pl. xx. figs. 12–14.—Catskill Group; Pennsylvania. [American Mus. Nat. Hist. New York.]

Holoptychius tuberculatus, J. S. Newberry, *ibid.* p. 101, pl. xix. fig. 14.—Chemung Group; Pennsylvania.

An indeterminable dermal plate from the Devonian of Belgium is also named *Holoptychius omaliusi*, L. Agassiz, Poiss. Foss. V. G. R. (1844), pp. 61, 75, pl. xxiv. fig. 11, and another fragment from the Eifel is assigned to the same species (*ibid.* p. 141).

Holoptychius falcatus and *H. striatus* are undefined names applied to Carboniferous fossils (L. Agassiz, Poiss. Foss. vol. i. 1844, p. xxxvi).

II. Glyptolepis.

Holoptychius (Glyptolepis) leptopterus, Agassiz.

[Plate XI. fig. 2.]

1841. *Glyptolepis*, H. Miller (*ex* Agassiz), Old Red Sandst. p. 81, pl. v. fig. 2.

1844. *Glyptolepis elegans*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 179 (name only).

1844. *Glyptolepis leptopterus*, L. Agassiz, *ibid.* p. 179 (name only).

1844. *Glyptolepis leptopterus*, L. Agassiz, Poiss. Foss. V. G. R. pp. 61, 63, pls. xx., xxi., pl. xxi. *a.* fig. 1.

1844. *Glyptolepis elegans*, L. Agassiz, *ibid.* pp. 61, 65, pl. xix. figs. 4, 5, pl. xxi. *a.* fig. 2.

1848. *Holoptychius sedgwickii*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 311. [Woodwardian Museum, Cambridge.]

1855. *Glyptolepis leptopterus*, F. M'Coy, Brit. Palæoz. Foss. p. 590.

1855. *Holoptychius sedgwickii*, F. M'Coy, *ibid.* p. 595, pl. ii. D. fig. 6.

1860. *Glyptolepis leptopterus*, C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. p. 62, pl. vii. figs. 4–9.

1888. *Glyptolepis leptopterus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 513.

Type. Portions of fishes; British Museum.

The type species of *Glyptolepis*, attaining a maximum length of about 0·5. Head and opercular apparatus occupying somewhat less than one-quarter of the total length. Pectoral fins very long, the distal extremity, when adpressed to the trunk, reaching beyond the origin of the pelvic pair; pelvic fins large, arising midway between the extremity of the snout and of the tail; first dorsal fin relatively small; second dorsal and anal equal in size, short and deep, directly opposed to each other; [caudal lobe apparently not excessively produced]. Scales externally ornamented with well-spaced, delicate, irregular antero-posterior ridges, often interrupted, sometimes bifurcating, and with fine scattered wrinkles in the interspaces; the ridges continued upon the overlapped portion of the scale by short, radiating lines of tubercles.

Form. & Loc. Lower Old Red Sandstone: Nairnshire, Banffshire, Cromarty, and Orkney.[1]

(i.) Lethen Bar, Nairnshire.

P. 538, P. 3287. The first of the type specimens, being an imperfect head, ventral aspect, in counterpart, figured by Agassiz, *tom. cit.* pl. xx. figs. 1, 4. In addition to the pair of jugular plates noted by Agassiz, two of the laterals of the right side appear to be distinct.

Egerton & Enniskillen Colls.

P. 539. Portions of head and anterior half of abdominal region of trunk, figured among the type specimens by Agassiz, *tom. cit.* pl. xx. fig. 5. The tuberculations of the head-bones and the ridge-ornament of the scales are only faintly indicated. *Egerton Coll.*

P. 542, P. 3289. Imperfectly preserved abdominal region, with one pectoral and portions of the pelvic fins, in counterpart, figured among the type specimens by Agassiz, *tom. cit.* pl. xxi. fig. 2. The acutely lobate pectoral fin is identified with the pelvic by Agassiz, while the pelvic is named first anal. *Egerton & Enniskillen Colls.*

[1] An indeterminable scale from the Devonian of Russia is also assigned to this species by Agassiz, Poiss. Poss. V. G. R. p. 139, pl. xxxi. *a*. fig. 24.

P. 541, P. 3288. Two imperfect examples of the caudal extremity, figured among the type specimens by Agassiz, *tom. cit.* pl. xxi. figs. 1, 3. In the original of fig. 3, the remains of the pelvic fins are misinterpreted as a first anal.
Egerton & Enniskillen Colls.

P. 3290, P. 4610. Three imperfect examples of the head and trunk, equalling the types in size. *Enniskillen Coll.*

P. 735 a, P. 740. Imperfect similar specimen, and portion of the extremity of the tail. *Egerton Coll.*

P. 735 b, P. 4609. Remains of head, pectoral arch, and anterior scales of an equally large individual.
Egerton & Enniskillen Colls.

20791. Ventral aspect of head and anterior abdominal region of a similar fish.
Presented by Col. Sir Proby T. Cautley, K.C.B., & — Gordon, Esq., 1847.

50106. Imperfectly preserved smaller individual, wanting paired fins, in counterpart. *Purchased*, 1879.

49179–80, 49194. Three imperfect small individuals, the first and, especially, the second displaying the paired fins.
Purchased, 1878.

(ii.) Tynet Burn, Banffshire.

37984. Imperfectly preserved individual as large as the type specimen, showing scattered bones of the head and pectoral arch, the left pectoral fin, and portions of the other fins.
Purchased, 1863.

41413. Equally large fish, broken and accidentally elongated.
Purchased, 1869.

P. 737–a, P. 738. Two portions of similar individuals, the first exhibiting a pectoral fin, the second showing the sculpture of the scales; also imperfect remains of a smaller fish wanting the head. *Egerton Coll.*

43280 a–b. Much crushed specimen of moderate size, in counterpart, wanting the extremity of the tail. *Purchased*, 1871.

35783, P. 738 a. Nodule with remains (i.) of a similar fish, wanting the head, in counterpart, and (ii.) of a less complete individual in another plane of stratification.
Purchased, 1860, *and Egerton Coll.*

37386. Imperfect, crushed specimen, showing some of the bones of the head. *Purchased*, 1863.

28863. Splintered mandibular ramus, with remains of other head-bones. *Purchased*, 1854.

(iii.) Gamrie, Banffshire.

P. 2075. Crushed individual, distinctly showing the ornament of the scales. *Egerton Coll.*

P. 4044. Somewhat larger specimen, in counterpart, displaying the pelvic and median fins, and the large club-shaped basal bone supporting the second dorsal. *Purchased*, 1883.

P. 4043. Smaller specimen, in counterpart, showing portions of all the fins and the scale-ornament. *Purchased*, 1883.

P. 4042. Well-preserved small specimen, in counterpart, shown, of the natural size, in Pl. XI. fig. 2. The head is so much crushed that little can be ascertained of its osteology. On the half not figured, the frontal bones occur, with a squamosal on each side, and a posterior element may be supratemporal; fragments of the mandible and some of the cheek-plates are shown, and the imperfect operculum and suboperculum occur behind, while the principal jugulars are displaced downwards. Of the pectoral arch the gently curved clavicular element is conspicuous on both sides of the fossil. The pectoral fins are almost completely destroyed, but one of the pelvic pair is well preserved, though the obtuse lobation is indistinct; the two dorsals and the anal are observed as described in the specific diagnosis; and the greater portion of the lower lobe of the caudal fin is shown, while its upper lobe is represented only by a few fragmentary rays. The relatively large size of the scales is evident, but few exhibit the exposed surface with its sculpturing. *Purchased*, 1883.

39181. Imperfect small specimen, ventral aspect. *Purchased*, 1865.

47873. Imperfect specimen, in counterpart, 0·165 in length. *Purchased*, 1877.

(iv.) Cromarty.

P. 5598. Imperfectly preserved specimen, 0·215 in length, showing portions of all the fins. *Harford Coll.*

(v.) Edderton, near Tain, Ross-shire.

P. 715. Small group of typical scales. *Egerton Coll.*

(vi.) Orkney Isles.

P. 3286. Fish with imperfectly preserved head, wanting the pectoral fins; Belyacreugh. *Enniskillen Coll.*

P. 3286 a. Imperfect remains of trunk and pelvic fins; Ramna Gio. *Enniskillen Coll.*

P. 703. Imperfect trunk and median fins; Belyacreugh. *Egerton Coll.*

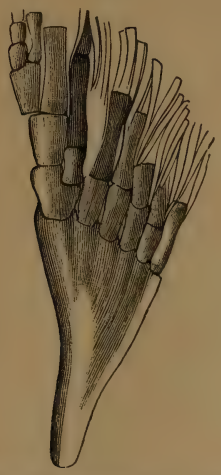
The following specimens pertain either to large individuals of this species or to *H. paucidens*:—

P. 537. Portion of mandible associated with large scales, described and figured by Agassiz, *op. cit.* pl. xx. figs. 2, 3; Lethen Bar. *Egerton Coll.*

30875, P. 713. Large head associated with similar scales, in counterpart; Lethen Bar. The specimen is vertically crushed and much broken, thus not exhibiting the precise outlines of any of the elements. The infraclavicular bones of the pectoral arch are seen posteriorly. *Purchased*, 1855, *and Egerton Coll.*

49178. Imperfectly preserved fish, about 0·5 in length, in counter-

Fig. 50.



Holoptychius (*Glyptolepis*) *leptopterus*, Ag.—Base of second dorsal fin. [No. 49178.

part; Lethen Bar. The fins are almost destroyed, but the supporting elements of the second dorsal are distinct, and are seen to consist of a single, club-shaped proximal bone, with about six transversely-jointed bars forming a distal series, as shown in the accompanying woodcut (fig. 50). *Purchased*, 1878.

P. 736, P. 3291. Small group of scales, in counterpart, labelled *Glyptolepis leptopterus* by Agassiz; Lethen Bar.
Egerton & Enniskillen Colls.

Holoptychius (Glyptolepis) quebecensis, Whiteaves.

1881. *Glyptolepis microlepidotus*, J. F. Whiteaves (*non* Agassiz), Canadian Nat. n. s. vol. x. p. 32.
1889. *Glyptolepis quebecensis*, J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 77, pl. v. fig. 4.
1890. *Glyptolepis quebecensis*, R. H. Traquair, Geol. Mag. [3] vol. vii. p. 16.

Type. Nearly complete fish; Geological Survey Museum, Ottawa.

A species closely related to *H.* (*Glyptolepis*) *leptopterus*, but not attaining so large a size, and differing, according to the original description and figure by Whiteaves, in the much smaller size of the pectoral fin and the greater attenuation of the caudal lobe.

Form. & Loc. Upper Devonian: Scaumenac Bay, P. Q., Canada.

Not represented in the Collection.

Holoptychius (Glyptolepis) paucidens (Agassiz).

1844. *Platygnathus paucidens*, L. Agassiz, Poiss. Foss. V. G. R. pp. 61, 78, pl. xxviii. fig. 11.
1849. "Scales, Under Jaw, Reptile Tooth, and Ischium of *Asterolepis*," H. Miller, Footprints of the Creator, p. 71, figs. 25, 26, 30–33, 42.
1888. *Glyptolepis paucidens*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 513.
1890. *Glyptolepis paucidens*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 483.

Type. Right mandibular ramus; British Museum.

A species attaining a relatively large size. Head and opercular apparatus occupying one-fifth of the total length. Pelvic fins arising considerably behind the middle point of the fish. Scales externally ornamented with well-spaced, delicate, irregular antero-posterior ridges, often interrupted, sometimes bifurcating, and with fine scattered wrinkles in the interspaces; the ridges continued upon the overlapped portion of the scale by short, radiating lines of tubercles.

Form. & Loc. Lower Old Red Sandstone: Orkney and Caithness.

P. 545. Imperfect right mandibular ramus, inner aspect, forming the type specimen described and figured by Agassiz, *loc. cit.*; Orkney. *Egerton Coll.*

P. 182. Imperfectly preserved head and trunk of a somewhat smaller individual, ventral aspect, in counterpart; Caithness. The ornamentation of the scales is especially well shown. *Purchased*, 1881.

P. 5934. A somewhat larger individual, ventral aspect, with portions of the median fins, but exhibiting only the inner surface of the scales; Achanarras, Caithness. *Purchased*, 1889.

33169. Fragment of squamation; Thurso. *Purchased*, 1857.

42401. Scale, abraded, but showing ornamentation; Castlehill, Caithness. *Peach Coll.*

Detached scales, not represented in the Collection, are also named thus:—

Glyptolepis benedeni, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. (1888), p. 150, pl. ix. figs. 3–5, pl. x. figs. 1, 2.—Upper Devonian; Belgium. [M. Lohest Collection, Liége.]

Glyptolepis radians, M. Lohest, *ibid.* p. 151, pl. ix. figs. 1, 2.—Upper Devonian; Belgium. [M. Lohest Collection.]

The supposed species, named as follows, are founded upon doubtful fragmentary evidence:—

Glyptolepis orbis, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. (1844), p. 832, and Leth. Rossica, vol. i. (1860), p. 1568, pl. lvi. fig. 6, pl. lvii. fig. 22.—Devonian; N.W. Russia. [Fragment of jaw and scales; University of St. Petersburg.]

Glyptolepis quadrata, E. von Eichwald, *ibid.* (1844), p. 832, and *ibid.* (1860), p. 1569.—Devonian; Marjina, R. Slawjanka. [Scales; University of St. Petersburg.]

Sclerolepis decorata, E. von Eichwald, *ibid.* (1844), p. 828, and vol. xix. (1846), pt. ii. p. 299, pl. x. figs. 16, 17, and Leth. Rossica, vol. i. (1860), p. 1570, pl. lvii. fig. 7.—Devonian; Marjina. [Scales in University of St. Petersburg, assigned to *Glyptolepis* by C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. (1860), p. 63.]

The detached large teeth of the Dendrodont Crossopterygians

have been described under the generic names of *Dendrodus* (R. Owen, Microscopic Journal, vol. i. 1841, p. 4) and *Lamnodus* (L. Agassiz, Poiss. Foss. V. G. R. 1844, pp. 61, 83). They have also received the following specific names :—

Dendrodus biporcatus, Owen.

1839. Tooth of *Megalichthys* or *Holoptychus*?, R. I. Murchison, Silurian System, p. 600, pl. ii. *bis.* figs. 8, 9.
1841. *Dendrodus biporcatus,* R. Owen, Microscopic Journal, vol. i. p. 5, woodc. figs. 1, 2, p. 19, woodc. fig. 5.
1841. *Dendrodus compressus,* R. Owen, *ibid.* p. 17, woodc. fig. 3.
1841. *Dendrodus biporcatus,* R. Owen, Odontogr. p. 171, pl. lxii. *a.* fig. 1, pl. lxii. *b.*
1841. *Dendrodus hastatus,* R. Owen, *ibid.* p. 175.
1841. Tooth of *Holoptychius,* H. Miller, Old Red Sandstone, p. xxiii, pl. ix. fig. 4.
1842. *Dendrodus biporcatus,* P. Duff, Geol. Moray, p. 67, pl. vi. fig. 5.
1842. *Dendrodus latus,* P. Duff, *ibid.* p. 67, pl. vi. fig. 4.
1842. *Dendrodus compressus,* P. Duff, *ibid.* p. 67, pl. vi. fig. 7.
1844. *Lamnodus panderi,* L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 162 (name only).
1844. *Lamnodus biporcatus,* L. Agassiz, Poiss. Foss. V. G. R. pp. 61, 84, 144, pl. C. figs. 7–9, 14–19, pl. xxviii. figs. 6, 7, pl. xxviii. *a.* figs. 14, 15.
1844. *Lamnodus panderi,* L. Agassiz, *ibid.* p. 61.
1844. *Dendrodus latus,* L. Agassiz, *ibid.* pp. 61, 82, pl. xxviii. figs. 1, 2.
1845. *Lamnodus hastatus,* L. Agassiz, *ibid.* p. 87, pl. C. figs. 1–6, 11–13.
1845. *Lamnodus sulcatus,* L. Agassiz, *ibid.* p. 145, pl. xxviii. *a.* fig. 18.
1860. *Dendrodus biporcatus,* C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. p. 53, pl. x. figs. 8–13, 17, 18.
1860. *Dendrodus biporcatus,* E. von Eichwald, Leth. Rossica, vol. i. p. 1559.
1880. *Dendrodus biporcatus,* H. Trautschold, Verhandl. russ.-kais. mineral. Ges. St. Petersburg, [2] vol. xv. p. 139, pls. iii.–v.
1889. *Dendrodus biporcatus,* J. V. Rohon, Mém. Acad. Imp. Sci. St. Pétersbourg, [7] vol. xxxvi. no. 14, p. 28, pl. i. fig. 2.

Type. Detached teeth.

The type species both of *Dendrodus* and *Lamnodus*, probably founded upon the dentition of *Holoptychius giganteus.* Teeth robust, straight or gently curved, attaining a large size ; round or oval in section in the basal portion, laterally compressed above, with a prominent pair of opposite longitudinal keels.

Form. & Loc. Upper Old Red Sandstone : Elgin. Devonian : N.W. Russia.

35995. Tooth wanting base, and fragment; Scat Craig, near Elgin.
Purchased, 1861.

43454. Six imperfect abraded teeth; Russia.
Presented by Kenneth Murchison, Esq., 1872.

41092. Thirty similar specimens; Dorpat, Livonia.
Purchased, 1868.

P. 4489. Fragment of Holoptychian mandible showing an internal dentary bone with parts of the bases of two teeth; River Ssjass, Govt. of St. Petersburg, Russia. The ornamented principal dentary, with a marginal series of small teeth, is also seen. *Purchased*, 1884.

Dendrodus strigatus, Owen.

1841. *Dendrodus strigatus*, R. Owen, Microscopic Journal, vol. i. p. 17, woodc. fig. 1.
1841. *Dendrodus sigmoideus*, R. Owen, *ibid.* p. 17, woodc. fig. 2.
1841. *Dendrodus strigatus*, R. Owen, Odontogr. p. 175.
1844. *Dendrodus strigatus*, L. Agassiz, Poiss. Foss. V. G. R. pp. 61, 80, 143, pl. C. figs. 10, 20–22, pl. xxviii. *a.* figs. 1, 2.
(?) 1844. *Dendrodus sigmoideus*, L. Agassiz, *ibid.* pp. 61, 82, 143, pl. xxviii. fig. 3, pl. xxviii. *a.* figs. 3–5.
(?) 1844. *Dendrodus strigatus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 105, pl. lv. *a.* figs. 19, 20.
1860. *Dendrodus strigatus*, C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. p. 53, pl. x. figs. 15, 16.
1860. *Dendrodus sigmoides*, C. H. Pander, *ibid.* p. 54, pl. x. fig. 19 (? fig. 20).

Type. Imperfect tooth.

Teeth much elongated, often sigmoidally curved, round in section, with a pair of inconspicuous longitudinal keels in the upper portion.

The Russian specimens commonly assigned to this "species" are more robust than those from the typical Scottish locality.

Form. & Loc. Upper Old Red Sandstone: Scat Craig, near Elgin. Devonian: N.W. Russia.

35996. Five imperfect typical teeth; Scat Craig. *Purchased*, 1861.

P. 5097. Typical tooth; Scat Craig.
Presented by John Edward Lee, Esq., 1885.

43454 a. Three imperfect robust teeth; Riga.
Presented by Kenneth Murchison, Esq., 1872.

Other Dendrodont teeth have also been described under the following names:—

Dendrodus acutatus, C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. (1860), p. 55, pl. x. fig. 14.—Devonian; Livonia. [Tooth, with fragment of internal dentary; School of Mines, St. Petersburg.]

Dendrodus briarti, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. (1888), p. 118, pl. viii. fig. 3.—Upper Devonian; Belgium. [M. Lohest Collection, Liége.]

Dendrodus inflexus, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1562, pl. lvii. fig. 18: *Saurichthys inflexus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xix. (1846), pt. ii. p. 310, pl. x. figs. 35–37.—Devonian; Marjina, near Pawlowsk. [University Museum, St. Petersburg.]

(?) *Dendrodus lævis*, C. G. Giebel, Abh. Naturw. Vereins für Sachsen u. Thüringen, vol. i. (1858), p. 263, pl. i. fig. 3; E. Kayser, Abh. Specialk. Preuss. u. Thüring. Staaten, vol. ii. pt. 4 (1878), p. 5, pl. i. fig. 18.—Lower Devonian; Harz Mountains.

Dendrodus minor, L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 144, pl. xxviii. *a*. fig. 13.—Devonian; Megra, Russia.

Dendrodus tenuistriatus, L. Agassiz, *ibid.* p. 143, pl. xxviii. *a*. figs. 6, 7; C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. (1860), p. 54, pl. x. figs. 21, 22.—Devonian; near St. Petersburg, and Prikscha.

Dendrodus traquairi, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. (1888), p. 117, pl. viii. figs. 2, 5 (ascribes also to this species, pl. xxviii. *a*. figs. 3–5 of Agassiz, and pl. x. fig. 20 of Pander).—Upper Devonian; Belgium (? Scotland and N.W. Russia). [M. Lohest Collection.]

Lamnodus minor, M. Lohest, *ibid.* p. 120, pl. vii. fig. 1.—Upper Devonian (Famennian); Liége, Belgium. [M. Lohest Collection.]

Apedodus priscus, J. Leidy, Journ. Acad. Nat. Sci. Philad. [2] vol. iii. (1856), p. 164, pl. xvii. figs. 5, 6.—Catskill Group; North Pennsylvania. [Academy of Sciences, Philadelphia.]

Numerous Dendrodont teeth from the Devonian of Dorpat are assigned to the reptiles *Varanus* and *Ichthyosaurus* by S. Kutorga, Beitr. Geogn. u. Paläont. Dorpat's, pt. i. (1835), pt. ii. (1837); figures and descriptions are given, and five supposed new species of *Varanus* are determined.

Family RHIZODONTIDÆ.

Body fusiform, robust, elongated, and somewhat depressed, with cycloidal scales, more or less deeply overlapping, exhibiting a rounded boss or short rib on the middle of the inner side, and sometimes covered externally with a thin layer or detached rugæ of ganoine. Head and opercular apparatus with well-developed membrane-bones; parietals large and separate, frontals separate, and orbits far forwards; interoperculum absent; jugular plates comprising one large pair, flanked on either side by a lateral series, and with a small azygous element in front. Dentary bone of mandible thin and vertical, with well-developed infradentaries in the same plane; an inner series of a few large, narrow, shuttle-shaped bones, each supporting a "laniary" tooth; a pair of similar teeth on the roof of the mouth, but the marginal upper dentition feeble. Teeth conical, with a pulp-cavity of which the walls are vertically folded towards the base. Pectoral and pelvic fins obtusely lobate; two remote dorsal fins, the first nearly opposite or directly opposed to the pelvic pair; anal fin single, caudal fin diphycercal or heterocercal.

Synopsis of Genera.

I. Infraclavicle with long upwardly directed process.
- Teeth smooth, with a pair of sharp edges. — *Rhizodus* (p. 342).
- Teeth rounded in section ..... — *Strepsodus* (p. 348).

II. Infraclavicle without an ascending process; dorsal fins directly opposed to pelvic and anal fins.
- Teeth rounded in section, smooth; ring-vertebræ; tail heterocercal, and caudal fin rhomboidal..... — *Rhizodopsis* (p. 354).
- No ring-vertebræ; tail almost diphycercal, and caudal fin rhomboidal ..... — *Gyroptychius* (p. 358).
- Teeth rounded in section; ring-vertebræ; tail almost diphycercal and truncated. — *Tristichopterus* (p. 360).
- Teeth compressed, with a pair of sharp edges; ring-vertebræ; tail heterocercal and truncated..... — *Eusthenopteron* (p. 361).

Genus **RHIZODUS**, Owen.

[Odontography, 1840, p. 75.]

Syn. *Megalichthys*, L. Agassiz & S. Hibbert, Trans. Roy. Soc. Edinb. vol. viii. 1836, p. 202 (non *Megalichthys*, L. Agassiz, 1844 : see p. 378).

The typical genus, imperfectly known, comprising species of very large size. Infraclavicle with a long, slender, upwardly-directed process. External bones and scales superficially ornamented with tubercles, ridges, or reticulations of ganoine. Crown of teeth smooth, compressed to a sharp edge anteriorly and posteriorly. No ossified vertebræ.

So far as known, the genus *Rhizodus* is confined to the Lower Carboniferous, and its remains are very fragmentary. Of the fins, only the lobate pectoral has been discovered [1].

Rhizodus hibberti (Agassiz & Hibbert).

[Plate XII. figs. 1–4.]

1793. "Fishes' Teeth," D. Ure, Hist. Rutherglen & Kilbride, p. 330, pl. xix. figs. 4, 6.

1836. *Megalichthys hibberti*, Agassiz & Hibbert, Trans. Roy. Soc. Edinb. vol. xiii. p. 202, pl. viii. fig. 1 (*non* fig. 2), pl. ix. figs. 2, 3, 9, 10; woodc. on p. 183.

1837. *Megalichthys hibberti*, W. Buckland, Geol. & Mineral. ed. 2 vol. ii. p. 43, pl. xxvii. fig. 12.

1837. *Holoptychus hibberti*, W. Buckland, *ibid.* p. 43, pl. xxvii. figs. 9–11, 13, 14.

1841. *Rhizodus hibbertii*, R. Owen, Odontogr. vol. i. p. 75, vol. ii. p. 12, pl. xxxv. fig. 2, pls. xxxvi., xxxvii.

1844. *Holoptychius hibberti*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 180 (name only).

(?) 1843. *Phyllolepis tenuissimus*, L. Agassiz, *ibid.* p. 180 (name only).

1855. *Rhizodus hibberti*, F. M'Coy, Brit. Palæoz. Foss. p. 612.

1855. *Rhizodus gracilis*, F. M'Coy, *ibid.* p. 611, pl. iii. G. fig. 17. [Dentary; Woodwardian Museum, Cambridge.]

1865. *Rhizodus hibberti*, J. Young, Trans. Geol. Soc. Glasgow, vol. ii. p. 38.

1866. *Rhizodus*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 599 (except scales).

1876. *Rhizodus*, W. J. Barkas, Monthly Review Dental Surgery, vol. iv. p. 394, figs. lxxx., lxxxi.

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[1] R. H. Traquair, Ann. Mag Nat. Hist. [4] vol. xv. 1875, p. 267.

1877. *Rhizodus hibberti*, R. H. Traquair, Ann. Mag. Nat. Hist. [4] vol. xix. p. 303, and Proc. Roy. Soc. Edinb. vol. ix. p. 658.
(?) 1881. *Rhizodus*, T. Stock, Geol. Mag. [2] vol. viii. p. 77, and Trans. Edinb. Geol. Soc. vol. iv. p. 38.

Type. Portions of jaws with teeth; *olim* Hibbert Collection.

The type species, of very large size. Head and opercular bones superficially tuberculated; exposed area of scales also ornamented with fine granules, confluent into short wavy ridges towards the hinder margin; clavicle and infraclavicle superficially ornamented with delicate reticulating ridges and pits.

Form. & Loc. Calciferous Sandstones and Carboniferous Limestone Series: South Scotland. Redesdale Ironstone: Northumberland.

Unless otherwise stated, the following specimens were obtained from the Blackband Ironstone (Lower Carboniferous Limestone) of Gilmerton, near Edinburgh:—

24337. Imperfect mandible associated with remains of jugular plates, the right clavicle, and some stout fin-rays. Two of the infradentary bones are distinct on the right side. *Purchased*, 1849.

21222 a. Fragment of head showing three imperfect large mandibular teeth, doubtfully of this species. *Purchased*, 1847.

21222 b. Portions of mandible and jugular plates. *Purchased*, 1847.

20707. Plaster cast of portions of mandible, figured by Owen, *loc. cit.* *Purchased.*

21975 a. Portion of right dentary, with the anterior large tooth. *Purchased*, 1848.

39462. Imperfect right mandibular ramus. *Bowerbank Coll.*

21222 c. Left mandibular ramus, displaying three of the large teeth. *Purchased*, 1847.

40327. Anterior portion of right dentary with teeth. *Purchased*, 1867.

47716. Imperfect left mandibular ramus, inner aspect, and other remains. *Presented by Dr. Lauder Lindsay*, 1876.

21222 d. Portions of mandible, the right dentary showing two very large anterior teeth in close apposition. *Purchased*, 1847.

P. 718–20, P. 2071. Three portions of left mandibular rami, and a slab with remains of both rami of a mandible.
Egerton Coll.

P. 3316–18. Three specimens showing portions of mandible, the second being a left ramus displaying the infradentaries, and shown of one-third the natural size in Pl. XII. fig. 1.
Enniskillen Coll.

41111. Base of a very large mandibular tooth, with the supporting bone. *Bryson Coll.*

P. 3315. Tooth about 0·17 in length, wanting the apex, and fixed to the supporting bone. *Enniskillen Coll.*

24846–48. Three large mandibular teeth. *Purchased*, 1850.

40150. Crushed large mandibular tooth; Blackband (Carboniferous Limestone), Jordan Hill.
Presented by Archibald Smith, Esq., 1866.

41109–10, 41112–14. Five large mandibular teeth. *Bryson Coll.*

50010. Large mandibular tooth. *Trevelyan Bequest.*

P. 717. Three large mandibular teeth; Carboniferous Limestone, Lochgelly, Fife. *Egerton Coll.*

P. 3319. Three large mandibular teeth; Lochgelly.
Enniskillen Coll.

P. 5123. Tooth 0·14 in length. *Purchased*, 1886.

P. 717 a. Two imperfect large mandibular teeth; Calciferous Sandstone, Burdiehouse. *Egerton Coll.*

P. 4800. Four mandibular teeth, doubtfully of this species; Possil Blackband (Middle Carboniferous Limestone), Airdrie, Lanarkshire. One specimen, showing facettes, is represented, of the natural size, in Pl. XII. fig. 2.
Armstrong Coll., transferred from Mus. Science & Art, Edinburgh, 1884.

21975 b. Operculum, inner aspect; Burdiehouse. *Purchased*, 1848.

21222 e. Obscure remains of pectoral arch, with a few robust, unarticulated fin-rays. *Purchased*, 1847.

47717. Left clavicle broken across the middle and the upper portion somewhat displaced downwards. The exposed area is covered with the characteristic fine reticulations; the anterior concave border is thickened, somewhat bent

inwards, and bounded by a broad smooth space; the posterior border of the inferior expanded half is thin, and immediately behind and within this border in the upper half there extends an inwardly and backwardly directed plate expanding upwards.

Presented by Dr. Lauder Lindsay, 1876.

21222 f. Right clavicle, inner aspect, about 0·32 in maximum length, shown of one-third the natural size in Plate XII. fig. 3. The inferior half forms a broad triangular expansion, laterally compressed, and the superior extremity, though relatively thicker and smaller, is somewhat expanded in the same plane; midway the bone is antero-posteriorly compressed, thus having a twisted appearance, and the inflexion of the anterior border of the expanded areas gradually diminishes above and below from this point. The postero-superior inner plate noted in No. 47717 forms part of the upper expansion when viewed from the aspect shown in the specimen now figured, and here it is somewhat broken and distorted by pressure.

Purchased, 1847.

30533. Much crushed and broken left clavicle. *Purchased*, 1856.

24841. Right infraclavicle, inner aspect, exhibiting the elongated, rod-like, postero-superiorly directed process from the middle of its upper border. The bone is shown, of one-third the natural size, in Pl. XII. fig. 4, and is associated with portions of the right mandibular ramus.

Purchased, 1850.

35728. More imperfect example of the left infraclavicle, showing the characteristic external ornament of fine reticulations.

Purchased, 1859.

47726. Imperfect remains of infraclavicles associated with fragments of mandible. *Purchased*, 1876.

P. 721. Three imperfect scales; Burdiehouse. *Egerton Coll.*

P. 3323. Three imperfect scales; Burdiehouse. *Enniskillen Coll.*

An imperfect dentary bone from the St. Louis Limestone (Lower Carboniferous) of Alton, Illinois, U.S.A., in the Museum of Columbia College, New York, closely resembles the corresponding element of *R. hibberti*. The laniary teeth, however, seem to be more compressed, with sharper edges, and the specimen is thus

regarded as the type of a distinct species, *Rhizodus anceps*, J. S. Newberry, Trans. New York Acad. Sci. vol. vii. (1888), p. 165, and Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 191, pl. xliii. fig. 1.

An imperfect Rhizodont laniary tooth, perhaps of the same species, from the same formation and locality, is theoretically associated by Newberry with a fossil which appears to the present writer to be the superficially calcified meckelian cartilage of an Elasmobranch. These two specimens (in the Museum of Columbia College) form the basis of a supposed genus *Cœlosteus*, J. S. Newberry (Trans. New York Acad. Sci. vol. vi. 1887, p. 137), with the single species, *C. ferox* (*ibid.*, and Palæoz. Fishes N. America, 1889, p. 190, pl. xxxv. figs. 1–4).

Rhizodus ornatus, Traquair.

[Plate XII. figs. 5–9.]

1836. *Megalichthys hibberti*, Agassiz & Hibbert (*errore*), Trans. Roy. Soc. Edinb. vol. xiii. pl. viii. fig. 2 (scale).
1866. *Rhizodus*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 599 (scales only).
1875. *Rhizodus hibberti*, R. H. Traquair (*non* Ag. & Hibb.), Ann. Mag. Nat. Hist. [4] vol. xv. p. 266.
1875. *Rhizodus*, L. C. Miall, Quart. Journ. Geol. Soc. vol. xxxi. p. 624, woodc. (inferior aspect of head, showing jugular plates).
1877. *Rhizodus ornatus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix. p. 659.

Type. Anterior portion of fish; Edinburgh Museum.

A species much smaller than *R. hibberti*. Head, opercular and clavicular bones, and also scales, externally ornamented with very coarse tuberculations, usually confluent into nodose, often reticulating ridges. Clavicle and infraclavicle relatively narrower antero-posteriorly than in *R. hibberti*, and the scales thicker.

Form. & Loc. Calciferous Sandstones and Lower Carboniferous Limestone Series: South Scotland.

Unless otherwise stated, the following specimens were obtained from the Blackband Ironstone (Lower Carboniferous Limestone) of Gilmerton, near Edinburgh:—

P. 3345. Head and anterior portion of trunk, viewed from the ventral aspect. The mandible and portions of the jugular plates and operculum exhibit the superficial ornamentation of blunt tubercles and large, nodose, reticulating ridges; while

the clavicle of each side is marked externally with fainter, though almost equally coarse, reticulations. The last-named bone in each case is imperfect superiorly, but the lower expanded portion (Pl. XII. fig. 6) is relatively longer and narrower than the corresponding part of the clavicle in *R. hibberti* (Pl. XII. fig. 3). No traces of the pectoral fins are preserved, and most of the scales are seen only from the inner side. Some scale-fragments (Pl. XII. fig. 8), however, show that "the exposed area of the external surface is marked with short, interrupted, wavy, reticulating ridges, whose direction is mainly parallel with the posterior border of the scale; while in the interval between these, more delicate ridges are seen radiating from the centre" (Traquair). *Enniskillen Coll.*

P. 363. Portion of dentary with teeth, associated with imperfect scales. *Purchased*, 1881.

P. 3320. Portion of dentary with teeth; Burdiehouse. *Enniskillen Coll.*

P. 3321. Left principal jugular plate and operculum, associated with the infraclavicle of the right side. The operculum, with its characteristic ornamentation, is shown, of the natural size, in Pl. XII. fig. 5, and the infraclavicle, from the inner aspect, in fig. 7. As remarked by Traquair, the last-named bone has a relatively less antero-posterior measurement than the corresponding element in *R. hibberti*. *Enniskillen Coll.*

P. 3322–a. Operculum associated with left infraclavicle and other fragments; also two imperfect detached opercula. *Enniskillen Coll.*

36911–12. Operculum and (?) suboperculum. *Purchased*, 1863.

47718. One of the principal jugular plates, in counterpart; Calciferous Sandstone, Burdiehouse, near Edinburgh. *Presented by Dr. Lauder Lindsay*, 1876.

21223, 21421. Two small scales, inner aspect. *Purchased*, 1847.

21975. Group of scales. *Purchased*, 1848.

41125. Small scale, inner aspect. *Bryson Coll.*

15533. Small scale, inner aspect; Burdiehouse. *Purchased.*

21223 a. Group of scales; Burdiehouse. *Purchased*, 1847.

35663. Group of scales; Burdiehouse. *Bean Coll.*

36914. Scale, inner aspect, shown, of the natural size, in Pl. XII. fig. 9; Burdiehouse. *Purchased*, 1863.

P. 721. Three detached scales, and small group of three, all inner aspect; Burdiehouse. *Egerton Coll.*

P. 3323. Group of scales, inner aspect; Burdiehouse. *Enniskillen Coll.*

The teeth and portions of jaws in the Museum of Columbia College, New York, described under the following names, are probably all Labyrinthodont:—

Rhizodus angustus, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. (1856), p. 99, and Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 342, pl. xxxix. fig. 6.—Coal-Measures; Linton, Ohio.

Rhizodus incurvus, J. S. Newberry, *ibid.* 1856, p. 99.—Coal-Measures; Linton, Ohio.

Rhizodus lancifer, J. S. Newberry, *ibid.* 1856, p. 99, and *ibid.* 1873, p. 342, pl. xxxix. fig. 9.—Coal-Measures; Linton, Ohio. [Very similar teeth from the Coal-Measures of Northumberland are also noticed (under the name of *R. lanceiformis*) by Hancock and Atthey, Ann. Mag. Nat. Hist. [4] vol. i. (1868), p. 271. These are determined to be *Pteroplax* both by the last-mentioned authors and by J. Young, Rep. Brit. Assoc. 1869, Trans. Sect. p. 101.]

Mioganodus laniarius, R. Owen (Trans. Odontol. Soc. vol. v. 1867, p. 357, pl. viii.), from the Coal-Measures of Northumberland, also sometimes referred to *Rhizodus*, is founded upon a microscopical section of a tooth, probably of the Labyrinthodont *Loxomma*. The type specimen is in the Collection. (**P. 6244.** *Presented by Sir Richard Owen, K.C.B.*, 1890.)

A scale of uncertain genus, but probably of *Strepsodus*, from the Coal-Measures of Illinois, is named *Rhizodus occidentalis*, Newberry & Worthen, Pal. Illinois, vol. ii. (1866), p. 19, woodc. fig. 2.

Genus **STREPSODUS**, Young.

[Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 602.]

Syn. *Dendroptychius*, J. Young (*ex* Huxley, MS.), Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 601.

Archichthys, A. Hancock & T. Atthey, Ann. Mag. Nat. Hist. [4] vol. v. 1870, p. 268.

Labyrinthodontosaurus, T. P. Barkas, Coal-Meas. Palæont. 1873, p. 75.

An imperfectly known genus, comprising species of medium or large size. Teeth subulate, without longitudinal keel, more or less bent inwards, and often sigmoidally curved; outer face nearly or quite smooth, inner face with vertical striations. Vertebral centra in the form of thin discs, pierced by a large mesial foramen for the passage of the remnant of the notochord. Scales very thin and deeply imbricating; inner surface with a median, antero-posteriorly elongated protuberance, and a hinder sector marked by small pits; exposed surface relatively small, ornamented with few, large, longitudinal furrows, somewhat radiating and occasionally branching.

The clavicle and infraclavicle of this genus are identical in form with those of *Rhizodus* described above (pp. 345, Pl. XII. figs. 3–6).

Strepsodus sauroides (Binney).

[Plate XVI. figs. 1, 2.]

1841. *Holoptychius sauroides*, E. W. Binney, Trans. Manchester Geol. Soc. vol. i. p. 165, pl. v. fig. 7.

1844. *Holoptychius sauroides*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 180 (name only).

1844. *Holoptychius garneri*, L. Agassiz, *ibid.* p. 180 (name only).

1864. *Holoptychius sauroides*, Kirkby & Atthey, Trans. Tyneside Nat. Field Club, vol. vi. p. 234, pl. vi. figs. 5, 6.

1866. *Strepsodus*, J. Young (*ex* Huxley, MS.), Quart. Journ. Geol. Soc. vol. xxii. p. 602, woodc. fig. 3.

1866. *Dendroptychius*, J. Young (*ex* Huxley, MS.), *ibid.* p. 601, woodc. fig. 7. [Scale; Museum of Practical Geology.]

1869. *Strepsodus*, T. P. Barkas, Scientific Opinion, vol. i. p. 556.

1872. *Strepsodus sauroides*, G. Lyon, Trans. Edinb. Geol. Soc. vol. ii. p. 125.

1873. *Labyrinthodontosaurus simmi*, T. P. Barkas, Coal-Meas. Palæont. pp. 75, 94, figs. 194, 223, 224. [Fragment of mandible; T. P. Barkas Collection, Newcastle-upon-Tyne.]

1873. *Strepsodus*, T. P. Barkas, *ibid.* p. 32, figs. 113–119.

1875. *Strepsodus sauroides*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 232.

1875. *Rhizodus* (*Holoptychius*) *garneri*, J. Ward, *ibid.* p. 233, fig. 4. [Scale; J. Ward Collection, Longton.]

1875. *Dendroptychius*, J. Ward, *ibid.* p. 233.

1876. *Strepsodus*, W. J. Barkas, Monthly Rev. Dental Surgery, vol. iv. pp. 481, 529, figs. lxxxvi.–lxxxviii.

1890. *Strepsodus sauroides*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 189.

1890. *Strepsodus sauroides*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 160, pl. ii. figs. 5, 25.

Type. Tooth; E. W. Binney Collection.

The type species. Teeth relatively long and slender, somewhat laterally compressed, often sigmoidally bent at the apex; inner face covered with prominent, thread-like, well-spaced striæ almost to the apex; basal folds very short. Jaw externally ornamented with fine tuberculations.

Form. & Loc. Coal-Measures: English, Scottish, and Irish Coal-fields.

P. 364. Three slabs of shale showing fragments of jaws and other head-bones associated with vertebræ and scales; Black-band, Airdrie, Lanarkshire. *Purchased*, 1881.

37323, 41999. Two fragments of mandible with imperfect teeth; Airdrie. *Purchased*, 1863, 1870.

P. 2287. Associated fragments of jaws; Carluke.
Presented by George Griffiths, Esq., 1882.

Fig. 51.

Strepsodus sauroides (Binney).—Tooth, natural size. Coal-Measures, England.

49119. Fragments of mandible showing one of the large teeth, and traces either of tubercular ornament, or a rugose surface left by the removal of superficial ganoine; Scotland.
Purchased, 1878.

21227, 21423. Twelve teeth, and small group of tooth-fragments; Carluke. *Purchased*, 1847.

37957. Large robust tooth; Airdrie. *Purchased*, 1863.

42000. Similar tooth, wanting the apex, but showing the basal folds; Airdrie. *Purchased*, 1870.

P. 4805. Small tooth; Palace Craig Ironstone, Carnbroe, Lanarkshire. *Armstrong Coll., transferred from Mus. Science and Art, Edinburgh*, 1884.

P. 6282. Imperfect small tooth; Low Main Seam, Newsham, Newcastle-upon-Tyne. *History unknown.*

P. 782. Large slender tooth with traces of basal folds; Lower Coal-Measures, Lowmoor, Yorkshire. *Egerton Coll.*

P. 1186. Three teeth; Middle Coal-Measures, Tingley, Yorkshire. *Egerton Coll.*

P. 3271. Three teeth; near Leeds. *Enniskillen Coll.*

P. 3270. Six teeth; Longton, Staffordshire. *Enniskillen Coll.*

P. 4090. Tooth; Old Hill, near Stourbridge. *Presented by Horace Pearce, Esq.*, 1883.

P. 5239. Crushed tooth; near Dudley. *Purchased*, 1886.

41634. Imperfect vertebra; Newsham, Newcastle-upon-Tyne. *Presented by T. P. Barkas, Esq.*, 1869.

41851 x. Imperfect vertebræ and associated fin-rays; Jarrow Colliery, Kilkenny, Ireland. *Purchased*, 1870.

38558–59. Two scales; Airdrie. *Purchased*, 1864.

P. 4579. Scale; Carluke. *Enniskillen Coll.*

19809, 19943. Four scales; Newsham, Newcastle-upon-Tyne. *Purchased*, 1845, 1846.

36478. Group of scales, the inner aspect of one shown, of two-thirds nat. size, in Pl. XVI. fig. 2; Longton. *Purchased*, 1862.

P. 4578. Scale; Longton. *Enniskillen Coll.*

40533. Scale showing impression of external furrows, represented of two-thirds nat. size in Pl. XVI. fig. 1; locality unknown. *Purchased*, 1867.

P. 4577. Scale labelled "*Megalichthys hibberti*" in Agassiz's handwriting; Jarrow Colliery, Kilkenny, Ireland. *Enniskillen Coll.*

Strepsodus striatulus, Traquair.

1882. *Strepsodus striatulus,* R. H. Traquair, Geol. Mag. [2] vol. ix. p. 544.
1890. *Strepsodus striatulus,* R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 389.

Type. Teeth; collection of Dr. R. H. Traquair.

Teeth not attaining so large a size as those of the typical species; never with a sharply-bent apex, and distinguished by the extreme fineness of the inner striæ, which are closely arranged.

Form. & Loc. Middle Carboniferous Limestone (Edge-Coal Series): Borough Lee, near Edinburgh, and Abden, Fife.

P. 4497. Two teeth. *Presented by Dr. R. H. Traquair,* 1884.

Strepsodus sulcidens (Hancock & Atthey).

1868. *Rhizodus hibberti,* Hancock & Atthey (*errore*), Ann. Mag. Nat. Hist. [4] vol. i. p. 346; also Nat. Hist. Trans. Northumb. and Durham, vol. iii. p. 81.
1870–71. *Archichthys sulcidens,* Hancock & Atthey, Ann. Mag. Nat. Hist. [4] vol. v. p. 268, and vol. vii. p. 79.
1872. *Archichthys sulcidens,* Hancock & Atthey, Nat. Hist. Trans. Northumb. & Durham, vol. iv. pp. 201, 393.
1873. *Archichthys,* T. P. Barkas, Coal-Meas. Palæont. p. 38, figs. 141, 142.
1876. *Archichthys sulcidens,* W. J. Barkas, Monthly Rev. Dental Surgery, vol. v. p. 7, figs. xci.–xciv.
1890. *Archichthys sulcidens,* R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 389.

Type. Mandibular ramus; Newcastle-upon-Tyne Museum.

The type species of "*Archichthys,*" attaining a relatively large size. Teeth robust, but elongated, somewhat laterally compressed, with a straight apex; striæ upon inner face very fine; broad, faint, vertically-elongated depressions extending upwards for a short space above the basal furrows.

Form. & Loc. Coal-Measures: Midlothian, Northumberland, and Staffordshire.

41116. Imperfect tooth; Dalkeith, near Edinburgh. *Purchased,* 1868.

45865 c. Tooth; Low Main Seam, Newsham, near Newcastle-upon-Tyne. *Purchased,* 1874.

P. 723–4. Two teeth; Newsham. *Egerton Coll.*

P. 3268. Tooth; Newsham. *Enniskillen Coll.*

P. 5136. Two teeth; Newsham.
Presented by William Dinning, Esq., 1886.

P. 785, P. 792. Two teeth; Longton, Staffordshire. *Egerton Coll.*

P. 3269. Tooth; Longton. *Enniskillen Coll.*

Strepsodus portlocki (Portlock).

1843. *Holoptychius portlockii*, J. E. Portlock (*ex* Agassiz, MS.), Rep. Geol. Londond. p. 464, pl. xiii. figs. 1–9.
1844. *Holoptychius portlockii*, L. Agassiz, Poiss. Foss. vol. i. p. xxxvi (name only).
1855. *Rhizodus hibberti*?, F. M'Coy, Brit. Palæoz. Foss. p. 613.
1878. *Archichthys portlockii*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix, p. 657.
1881. *Archichthys portlockii*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 18.
1888. *Rhizodus portlockii*, R. Etheridge, Foss. Brit. Islands, pt. i. p. 341.
1890. *Archichthys portlocki*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 389.

Type. Teeth and scales; Museum of Practical Geology.

Teeth closely similar to those of *S. sulcidens*, but apparently shorter and broader and without vertically-elongated depressions above the basal furrowed portion.

Form. & Loc. Lower Carboniferous: Derry, Tyrone, Fermanagh, and Antrim, N. Ireland. Calciferous Sandstones: Liddesdale, Dumfriesshire; Pittenween and Abden, Fifeshire.

P. 725. Imperfect small scales; Maghera, Co. Derry.
Egerton Coll.

P. 4580. Remains of larger scales; Maghera. *Enniskillen Coll.*

P. 4596. Group of similar scales; Ballynascreen, Derry.
Enniskillen Coll.

Strepsodus hardingi (Dawson).

1868. *Rhizodus hardingi*, J. W. Dawson, Acadian Geology, ed. 2, p. 254, fig. 77 *a–d*.
1890. *Strepsodus*, A. S. Woodward, Geol. Mag. [3] vol. vii. p. 457.

Type. Fragment of mandible and tooth; Peter Redpath Museum, Montreal.

Teeth much laterally compressed, sometimes facetted, slightly curved, with slender apex; fine striations distally on the concave side, but extending round the plicated basal portion.

Form. & Loc. Lower Carboniferous: Horton Bluff, Nova Scotia. Not represented in the Collection.

An undetermined small species, with teeth resembling those of *S. sauroides* (Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 18) is indicated by the following specimens :—

P. 4054. Two teeth, 0·01 in length, incurved at the apex; Calciferous Sandstones (Cement-stone Group), Eskdale, Dumfriesshire. *Purchased*, 1883.

P. 4054 a. Oval scale, 0·038 in long diameter; Eskdale. *Purchased*, 1883.

Scales, with associated teeth, from the Calciferous Sandstones of Pitcorthy, Fife, are also named *Strepsodus minor*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. (1890), p. 393. [Edinburgh Museum.]

Other scales much resembling those of *Strepsodus* have been described from the Upper Devonian of Mimers Dal, Spitzbergen, by E. R. Lankester, Handl. k. Svenska Vetensk. Akad. vol. xx. no. 9 (1884), p. 5, figs. 7–12. [State Museum, Stockholm.] Compare also *Saurichthys* (p. 364).

A fragmentary scale from the Chatham Series of North Carolina, figured under the name of *Rabdiolepis speciosus* by E. Emmons (Manual Geol. ed. 2, 1860, p. 183, fig. 161), also exhibits some resemblance to *Strepsodus*.

Genus **RHIZODOPSIS,** Young.

[Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 596[1].]

Syn. *Dittodus*, R. Owen, Trans. Odontol. Soc. vol. v. 1867, p. 325 (in part).
Ganolodus, R. Owen, *ibid.* p. 354 (in part).
Characodus, R. Owen, *ibid.* p. 366.
Gastrodus, R. Owen, *ibid.* p. 370.
Orthognathus, T. P. Barkas, Coal-Meas. Palæont. 1873, p. 38.

Body much depressed anteriorly, with narrow ovoid scales, of which the exposed portion is covered with a thin film of ganoine, while the inner face is marked by a median boss and punctations posteriorly. Teeth round in section, smooth. Vertebræ ring-shaped. First dorsal fin opposed to the pelvic pair, and the second dorsal to the anal; tail heterocercal, the caudal fin rhomboidal in form.

[1] This definition is said to be based upon the unpublished observations of Huxley. The generic name is incidentally mentioned by Huxley, Mem. Geol. Surv. dec. xii. (1866), p. 31, footnote.

The superficial film of ganoine upon the scales and external bones of this genus being very thin, it is usually destroyed. The scales, as a rule, exhibit a few concentric markings crossed by numerous very fine, radiating lines, due to the inner structural features.

The osteology of the head and branchiostegal apparatus has been described in detail by Traquair [1], who gives the restorations already described on p. 319 (fig. 47).

Rhizodopsis sauroides (Williamson).

1837. "Fossil Salmon," W. C. Williamson, Phil. Mag. [3] vol. xi. p. 300, pl. ii. figs. 4–6. [Scales.]

1841. *Holoptychius*, sp. nov., E. W. Binney, Trans. Manchester Geol. Soc. vol. i. p. 165, pl. v. fig. 6. [Dentary bones; E. W. Binney Collection.]

1841. *Holoptychius sauroides*, E. W. Binney (*errore*), *ibid.* p. 165, pl. v. figs. 8, 10. [Scales.]

1844. *Holoptychius granulatus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 180 (name only).

1849. *Holoptychius sauroides*, W. C. Williamson, Phil. Trans. p. 457, pl. xlii. figs. 21–23.

1861. *Rhizodus granulatus*, J. W. Salter, Foss. S. Welsh Coalfield (Mem. Geol. Surv.—Iron Ores Gt. Britain, pt. iii.), p. 223, pl. i. figs. 4–6 (also teeth, *ibid.* pl. i. figs. 1–3, 7–9).

1864. *Holoptychius, sp. indet.*, Kirkby & Atthey, Trans. Tyneside Nat. Field Club, vol. vi. p. 235, pl. vi. fig. 4.

1866. *Rhizodopsis sauroides*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 596, woodc. fig. 8.

1867. *Dittodus parallelus*, R. Owen, Trans. Odontol. Soc. vol. v. p. 325 pl. i. [Micro. section of jaw; British Museum.]

1867. *Ganolodus craggesii*, R. Owen, *ibid.* p. 356, woodcut. [Dentary bone; British Museum.]

1867. *Characodus confertus*, R. Owen, *ibid.* p. 366, pl. xiii. [Micro. section of tooth.]

1867. *Gastrodus præpositus*, R. Owen, *ibid.* p. 370, pls. xiv., xv. [Micro. section of jaw; British Museum.]

1868. *Rhizodopsis sauroides*, Hancock & Atthey, Ann. Mag. Nat. Hist. [4] vol. i. p. 349.

1870. *Rhizodopsis sauroides*, Hancock & Atthey, Nat. Hist. Trans. Northumb. & Durham, vol. iii. pp. 85, 91.

1873. *Orthognathus reticulosus*, T. P. Barkas, Coal-Meas. Palæont. p. 38, figs. 143, 144. [Portions of jaws; T. P. Barkas Collection.]

1873. *Rhizodopsis*, T. P. Barkas, *ibid.* p. 23, figs. 59–69.

1875. *Rhizodopsis sauroides*, J. Ward, [Proc.] N. Staffs. Nat. Field Club p. 231.

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[1] Trans. Roy. Soc. Edinb. vol. xxx. (1881), p. 169, woodcuts figs. 1–3

1876. *Rhizodopsis sauroides*, W. J. Barkas, Monthly Rev. Dental Surgery, vol. iv. p. 433, figs. lxxxii.–lxxxv.
1876. *Orthognathus*, W. J. Barkas, *ibid.* p. 530, figs. lxxxix., xc.
1881. *Rhizodopsis sauroides*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 169, woodc. figs. 1–3.
1890. *Rhizodopsis sauroides*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 161, pl. viii. figs. 5–8.
1890. *Rhizodopsis sauroides*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 389.

Type. Scales; unknown.

The type species; much elongated and attenuated in the caudal region, attaining a length of 0·5, but usually about half this size. Head with opercular apparatus occupying about one-fifth of the total length; parietal region of cranium longer than broad, much longer than the frontal and rostral region; principal jugulars about three times as long as their maximum breadth; operculum as deep as broad. Pelvic fins arising behind the middle point between the pectoral fins and the extremity of the caudal; posterior dorsal fin and the anal of equal size, much deeper than long, symmetrical. Scales thin, elongate oval, obtusely pointed behind; the exposed area rhomboidal in shape, marked with concentric ridges when abraded.

Form. & Loc. Coal-Measures: English, Welsh, and Scottish Coal-fields.

P. 794. Head and greater portion of trunk, ventral aspect; Knowles Ironstone, Fenton, N. Staffordshire. *Egerton Coll.*

P. 5196–98. Six portions of head and trunk, some showing fins; Knowles Ironstone, N. Staffordshire. The first shows the ring-shaped vertebræ, and the second also the pectoral fins; another exhibits a large, antero-posteriorly elongated scale on the inner side of the base of the pelvic fins. *Purchased*, 1885.

P. 796. Imperfect head and anterior scales; Deep-mine Ironstone Shale, Longton, N. Staffordshire. *Egerton Coll.*

P. 3267. Portions of head, pectoral fin, and anterior abdominal region, partly in counterpart; Knowles Ironstone Shale, Fenton. *Enniskillen Coll.*

P. 3266. Imperfect head, with pectoral fin and anterior scales; Low Main Seam, Newsham, near Newcastle-upon-Tyne. *Enniskillen Coll.*

P. 5195. Portions of head, pectoral fin, and anterior scales; Dale-moor Rake Ironstone, Stanton-by-Dale, Derbyshire. *Purchased*, 1885.

P. 4794. Dentary bone, forming the type specimen of *Ganolodus craggesii*, Owen; registered as obtained from Ruabon.
Egerton Coll.

P. 6247. Longitudinal section of jaw prepared for microscopical examination; the type specimen of *Gastrodus prælositus*, Owen; Low Main Seam, Newsham, Northumberland.
Presented by Sir Richard Owen, K.C.B., 1890.

30571. Extremity of tail of a large fish, showing the second dorsal, anal, and greater portion of the caudal fin; Stanton-by-Dale. *Purchased*, 1856.

P. 5198 a. Ventral scales and imperfect pectoral fins of a large fish; Hanley. *Purchased*, 1885.

42261. Group of fragmentary scales and other remains; Bilston, Staffordshire. *Baugh Coll.*

41633. Group of imperfect large scales; Newcastle-upon-Tyne.
Presented by T. P. Barkas, Esq., 1869.

21421 a. Four scales, inner aspect; Carluke, Lanarkshire.
Purchased, 1847.

41131. Scale, inner aspect; Carluke. *Bryson Coll.*

44148. Scale, outer aspect; Newcastle-upon-Tyne.
Purchased, 1873.

44855. Impression of inner aspect of scale; Pendleton, Manchester.
Presented by Benjamin Bright, Esq., 1873.

P. 4583. Scale, inner aspect; Ruabon. *Enniskillen Coll.*

Rhizodopsis robusta, sp. nov.

[Plate XVI. fig. 3.]

1865. *Rhizodus hibberti*, F. Roemer (*errore*), Zeitschr. deutsch. geol. Ges. vol. xvii. p. 272, pl. vi. figs. 2, 5 (? *non* figs. 1, 3).
1866. *Rhizodopsis*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 598.

Type. Scale; British Museum.

An imperfectly definable species, distinguished from the type by the more robust character of the squamation. The abraded exposed portion of each scale is marked by thick rounded ridges, concentric with the hinder free border, and sometimes nodose.

The smaller scale and the tooth figured by Roemer pertain to this species; but the larger scales described and figured by the same author are more suggestive of those of *Strepsodus*.

Form. & Loc. Coal-Measures: Glatz, Silesia.

P. 4587. Type scale, well preserved, much resembling the original of Roemer's fig. 2, but less symmetrical; shown, of three-halves the natural size, in Pl. XVI. fig. 3; Volpersdorf, Glatz. *Enniskillen Coll.*

P. 4586. Right operculum, 0·019 in depth, and equally broad, the hinder border sharply angulated about its middle point, and the lower border twice as long as the upper; Volpersdorf. *Enniskillen Coll.*

The following specimens also pertain to this genus:—

P. 789. Two small scales, inner aspect; Coal-Measures, Pictou, Nova Scotia. *Egerton Coll.*

Genus **GYROPTYCHIUS**, M'Coy.

[Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 307.]

Syn. *Glyptolepis*, L. Agassiz, Poiss. Foss. V. G. R. 1844, p. 62 (in part).

Body much depressed anteriorly, with ovoid scales, of which the exposed portion is probably covered with a thin film of ganoine, while the inner face is marked by a prominent median ridge and punctations posteriorly. Head-bones tuberculated. No ossified vertebræ. First dorsal fin opposed to the pelvic pair, and the second dorsal to the anal; tail almost diphycercal, the upper lobe of the rhomboidal caudal fin being relatively large.

This genus comprises fishes of small size, and is very closely related to *Rhizodopsis*: the scales appear to differ from those of the latter merely in the substitution of a prominent long ridge for the median inner boss.

Gyroptychius microlepidotus (Agassiz).

1844. *Glyptolepis microlepidotus*, L. Agassiz, Poiss. Foss. V. G. R. p. 65, pl. xxi. *a*. figs. 3–7.

1848. *Gyroptychius angustus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 308, woodc. figs. *a–c*. [Woodwardian Museum, Cambridge.]

1855. *Gyroptychius angustus*, F. M'Coy, Brit. Palæoz. Foss. p. 596, pl. ii. c. fig. 2.

1860. *Gyroptychius angustus*?, C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. p. 79, pl. vi. figs. 1–7, pl. vii. figs. 1–3.

1861. *Gyroptychius*, T. H. Huxley, Figs. and Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 3, woodc. fig. 3.

1875. *Gyroptychius angustus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxvii. p. 395.

1888. *Gyroptychius microlepidotus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 514.

Type. Imperfect fishes ; British Museum and Forres Museum.

The type species, attaining a maximum length of about 0·3. Head with opercular apparatus contained about four and a half times in the total length ; parietal region equal to the fronto-ethmoidal in length, and the upper part of the anterior extremity of the snout covered with separate polygonal plates ; jaws much elongated. Pelvic fins arising in advance of a point midway between the operculum and the extremity of the tail ; dorsal fins higher than long, the first smaller than the second, and the latter about equal in size to the opposing anal. Scales small.

Form. & Loc. Lower Old Red Sandstone : Nairnshire, Banffshire, and Orkney [1].

P. 340. One of the type specimens figured by Agassiz, *op. cit.* pl. xxi. *a.* fig. 3 ; Lethen Bar, Nairnshire. *Egerton Coll.*

50104. Fish, in counterpart, showing portions of several head and opercular bones, the clavicles, and fragments of the fins ; Lethen Bar. The inner ridge upon the scales is very prominent. *Purchased*, 1879.

41891. Head and abdominal region of small fish ; Tynet Burn, Banffshire. *Purchased*, 1870.

43014. Small fish, in counterpart, showing the obtusely lobate pectoral fins and portions of the pelvics, dorsals, and anal, but wanting the caudal fin ; Tynet Burn. *Purchased*, 1871.

43271. Small fish showing portions of the fins ; Tynet Burn. *Purchased*, 1871.

36071. Scattered scales and various bones of a large fish ; Tynet Burn. *Purchased*, 1861.

P. 4045. Large well-preserved fish, 0·3 in length, in counterpart ; Gamrie, Banffshire. The head is vertically crushed, and one side of the counterpart exhibits the cranial roof from the inner aspect, while the other gives an imperfect inner view of the principal jugulars. The parietal and fronto-ethmoidal regions of the cranial roof are well separated by a transverse suture ; and there is a median suture between the frontals, marked at one point either by a large excavation on the inner surface of the closely apposed bones, or by a foramen, such as exists in *Osteolepis* and *Diplopterus*.

[1] Fragments from the Devonian of Livonia are also assigned to this species by E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1564.

The ethmoidal region is covered with numerous polygonal ossifications; and the forward position of the orbit is well shown. The cheek is covered by membrane-bones of which the very large posterior element is distinct; and immediately below these occurs the long slender maxilla, provided with a series of small teeth. The form and proportions of the operculum and suboperculum are also shown, from the inner aspect, on the left side. Of the fins, the anal and caudal are best preserved; and a pair of relatively large narrow scales seems to occur in advance both of the first dorsal and the anal. *Purchased*, 1883.

28870, P. 716. Imperfect smaller fish, in counterpart; Gamrie. *Purchased*, 1854, *and Egerton Coll.*

P. 4046. Head and portions of trunk of small fish; Gamrie. *Purchased*, 1883.

P. 184–5. Two examples of the head with imperfect trunk, the second in counterpart; Orkney. *Purchased*, 1881.

An imperfect scale of an indeterminable genus, from a Lower Palæozoic boulder near Meseritz, Silesia, is named *Gyroptychius posnaniensis*, G. Kade, Programm k. Realschule zu Meseritz, 1858, p. 16, figs. 6, 7.

Genus **TRISTICHOPTERUS**, Egerton.

[Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv. 1861), dec. x. p. 51.]

Body much depressed anteriorly, with round or ovoid scales, of which the exposed portion is ornamented with short, antero-posteriorly directed rugæ of ganoine. Head-bones more or less tuberculated; teeth round in section. Ossified ring-shaped vertebræ in the abdominal region. Anterior dorsal fin opposed to the pelvic pair, and the posterior dorsal to the anal; tail heterocercal, the caudal fin abruptly truncated posteriorly, having a relatively small upper lobe, and the rays at the extremity of the caudal body-prolongation extending somewhat beyond the others above and below.

Tristichopterus alatus, Egerton.

1861. *Tristichopterus alatus*, Sir P. Egerton, Rep. Brit. Assoc. 1860, Trans. Sect. p. 78, and Figs. and Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 51, pls. iv., v.

1875. *Tristichopterus alatus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. viii. p. 513.

1875. *Tristichopterus alatus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxvii. p. 383, pl. xxxii.

Type. Imperfect fishes; Museum of Practical Geology and British Museum.

The type species, attaining a length of about 0·3. Maximum depth of trunk nearly equal to the length of the head, and contained about six and a half times in the total length. Head somewhat longer than deep; operculum deeper than broad; all the bones ornamented with granulations, more or less fused into short tortuous rugæ. Pelvic fins about three quarters the size of the pectorals, arising immediately behind the middle point of the trunk, and opposed to the somewhat smaller anterior dorsal fin; posterior dorsal and anal fins of nearly equal size, deeper than broad, and much larger than the anterior dorsal; length of caudal fin much less than its maximum depth. Scale-ornament very fine and closely arranged.

Form. & Loc. Lower Old Red Sandstone: Caithness.

All the specimens mentioned below are comprised in the Peach Collection, and were obtained from the neighbourhood of John o'Groats.

42396. Counterpart of one of the type specimens figured by Egerton, *loc. cit.* pl. v.

42397. Fish, showing well-preserved caudal region, noticed by Traquair, *loc. cit.* 1875, p. 384.

42398. Imperfect head and anterior part of abdominal region, with right pectoral fin. The tubercular and partly rugose ornamentation of the head-bones is distinct, and portions of the broad, ring-shaped vertebræ occur.

42406. Imperfect trunk with part of the head and large portions of the fins.

42407. Part of the squamation of a large fish, with remains of the axial endoskeleton and some of the fin-supports.

Genus **EUSTHENOPTERON,** Whiteaves.

[Canadian Naturalist, n. s. vol. x. 1881, p. 30.]

Body much depressed anteriorly, with round or ovoid scales, of which the exposed portion is ornamented with granulations and antero-posteriorly directed rugæ. Head-bones more or less tuber-

culated; teeth compressed, with a sharp anterior and posterior edge. Ossified ring-shaped vertebræ in the abdominal region. Infraclavicle without an ascending process. Anterior dorsal fin opposed to the pelvic pair, and the posterior dorsal to the anal; tail diphycercal or slightly heterocercal, the caudal fin large and triangular, abruptly truncated or excavated posteriorly, the upper lobe nearly or quite as large as the lower, and the rays at the extremity of the caudal body-prolongation extending somewhat further backwards than the others.

Eusthenopteron foordi, Whiteaves.

1881. *Eusthenopteron foordi*, J. F. Whiteaves, Canadian Naturalist, n. s. vol. x. p. 31, woodc.

1889. *Eusthenopteron foordi*, J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 79, pl. v. fig. 5, pls. vi., vii., and woodc. fig. 1.

1889. *Phaneropleuron curtum*, J. F. Whiteaves (*errore*), *ibid.* p. 91, pl. x. fig. 1.

1890. *Eusthenopteron foordii*, R. H. Traquair, Geol. Mag. [3] vol. vii, p. 17.

Type. Imperfect fish; Geological Survey Museum, Ottawa.

The type species, attaining a maximum length of not less than 0·6. Head longer than deep, occupying somewhat more than one sixth of the total length; the bones ornamented with granulations more or less fused into short tortuous rugæ. Pelvic fins much smaller than the pectorals, arising about the middle point of the trunk, directly opposed to an anterior dorsal fin of nearly equal size; anal and posterior dorsal fins relatively large, very high, narrow, and acuminate, equal and opposite, situated close to the base of the caudal fin; caudal fin about as long as deep, having the hinder border much excavated above and below the caudal body-prolongation. Scale-ornament very delicate.

The fine state of preservation in which this species is discovered renders it possible to determine many points in the structure of the endoskeleton—notably the arrangement of the basal cartilages of the fins, which closely resemble those of *Tristichopterus*. A distinct ring of sclerotic plates round the eye is also conspicuous in some of the type specimens.

Form. & Loc. Upper Devonian: Scaumenac Bay, P. Q., Canada.

P. 5219. Fish, 0·25 in length, with imperfectly preserved head, displaying all the fins except the pectorals.

Presented by A. H. Foord., Esq., 1886.

P. 5482–84. Three typical small specimens, the third showing portions of the vertebræ in the abdominal region.
Purchased, 1888.

P. 5976–78. Portions of large individuals. *Purchased*, 1889.

The two following genera are proved by their dentition to pertain to the Rhizodontidæ, but are as yet too imperfectly known for precise definition.

Genus **CRICODUS**, Agassiz.

[Poiss. Foss. vol. ii. pt. ii. 1844, p. 156, pl. H. figs. 9–12.]

Syn. *Polyplocodus*, C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. 1860, p. 28.

Bones of fronto-ethmoidal shield fused into a single piece. Teeth rounded in section, with a large pulp-cavity. [Exposed portion of scales probably tuberculated.]

Cricodus incurvus (Duff).

1842. *Dendrodus incurvus*, P. Duff, Geol. Moray, p. 68, pl. vi. fig. 11.
1844. *Cricodus incurvus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 162 (name only).
1844. *Cricodus incurvus*, L. Agassiz, Poiss. Foss. V. G. R. pp. 61, 88, pl. xxviii. figs. 4, 5.

Type. Tooth; (?) collection of James Powrie, Esq., Reswallie.
The type species, founded upon a small, stout, recurved tooth about 0·013 in length.
Form. & Loc. Upper Old Red Sandstone: Scat Craig, Elgin. Upper Devonian: Riga.
Not represented in the Collection.

Cricodus wenjukowi, Rohon.

1860. *Polyplocodus incurvus*, C. H. Pander (*errore*), Saurodipt., Dendrodont. &c. devon. Syst. pp. 82, 84, 86, pl. x. fig. 23, pls. F, G, pl. L. figs. 1–5.
1880. *Dendrodus biporcatus*, H. Trautschold (*errore*), Verhandl. russ.-kais. mineral. Ges. [2] vol. xv. p. 139, pls. iii.–v.
1889. *Cricodus* (*Polyplocodus*) *wenjukowi*, J. V. Rohon, Mém. Acad. Imp. Sci. St.-Pétersbourg, [7] vol. xxxvi. no. 14, p. 49, pl. i. figs. 3, 4, 6, 11, pl. ii. figs. 12, 14, 19.
(?) 1889. *Dendrodus biporcatus*, J. V. Rohon (*errore*), *ibid.* p. 49, pl. i. figs. 1, 9.
1890. *Cricodus*, H. Trautschold, Zeitschr. deutsch. geol. Ges. vol. xli. p. 629, pls. xxiii.–xxv.

Type. Anterior portion of skull; University of St. Petersburg.

A species attaining a larger size than the type, and having the teeth almost or quite erect to the apex. Snout gently rounded and head-bones externally ornamented with coarse granulations, which are rarely fused together into short vermiculating series.

As remarked by R. H. Traquair (Geol. Mag. [3] vol. vi. 1889, p. 491), the specimens described under this name by Rohon as entire skulls are merely fragmentary examples of the region in advance of the parietal bones. The pair of large teeth shown in these fossils is borne by the vomers, and the supposed orbits are probably the nasal openings.

The tuberculated scales described and figured by Rohon (*loc. cit.* p. 6, pl. i. figs. 7, 8, pl. ii. figs. 13, 15, 16, 17, 18, 20) may possibly pertain to this species, but Trautschold remarks (*loc. cit.* 1890, p. 622) that such scales have not yet been found in the same localities as the jaws. The specimens are preserved in the School of Mines, St. Petersburg, and the University of Dorpat.

Form. & Loc. Devonian: Government of St. Petersburg, and (?) Livonia.

28871. Base of large mandibular tooth affixed to part of the supporting bone; locality unknown. *Purchased*, 1854.

P. 4733. Two similar specimens, one of them showing the outer series of small teeth, and also a detached tooth wanting the apex; River Ssjass. *Purchased*, 1884.

To this, or to the following genus, may also probably be assigned the species described thus:—

Cricodus (?) *agassizi*, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. (1888), p. 120, pl. vii. fig. 4, pl. viii. fig. 1.—Upper Devonian; Belgium. [Imperfect dentary and teeth; M. Lohest Collection, Liége.]

Genus **SAURIPTERUS**, Hall.

[Nat. Hist. New York, pt. iv. Geology, 1843, p. 282 (*Sauripteris*).]

Head-bones, operculum, jugular plates, and clavicular bones ornamented with tubercles, more or less fused into short, vermiculating ridges. Teeth compressed to the base with a pair of sharp edges; pulp-cavity large. Ossified ring-vertebræ present. Scales [according to J. S. Newberry] having "the covered portion beautifully reticulated with large elongated meshes, the exposed portion

thickly set with fine conical or rounded granules, generally without linear arrangement."

The type species of this genus is *S. taylori*, J. Hall, Nat. Hist. New York, pt. iv. Geology, 1843, p. 282, woodc. fig. 130 (1) (further noticed by J. S. Newberry, Palæoz. Fishes N. America, 1889, p. 112), founded upon portions of a fish from the Catskill Group of Blossburgh, Pennsylvania, now in the American Museum of Natural History, New York. A personal examination of the original specimen has convinced the present writer (Geol. Mag. [3] vol. vii. 1890, p. 392) that the arrangement of the cartilages in the obtusely lobate pectoral fin and the structure of the teeth suffice to determine the Rhizodont character of the fish. It may also be added that the writer did not observe the external tubercular scale-ornament noted by Newberry, while the reticulated markings suggested to him the corresponding ornamentation on the exposed portion of the scales of *Strepsodus* (see Pl. XV. fig. 1).

The two following species are only provisionally placed here until the discovery of more satisfactory specimens.

Sauripterus favosus (Agassiz).

1844. *Glyptosteus favosus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 179 (name only).

1844. *Bothriolepis favosa*, L. Agassiz, Poiss. Foss. V. G. R. pp. 61, 100, pl. xxvii. fig. 7, pl. xxviii. figs. 12, 13.

1860. *Dendrodus favosus*, E. von Eichwald, Leth. Rossica, vol. i. p. 1561 (in part).

1888. *Cricodus* (?) *favosus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 515.

1890. *Cricodus* (?) *favosus*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 48.

Type. Portions of jaws; unknown.

Laniary teeth much compressed, very broad at the base, tapering to a slender, faintly recurved apex. External surface of mandible coarsely tuberculated; some of the head-bones more finely marked, the granulations tending towards arrangement in series. [Scales and vertebræ unknown.]

The known examples of the jaws of this species are about 0·25 in length, and a typical laniary tooth measures 0·015 in height. The fragmentary plates from the Russian Old Red Sandstone, theoretically associated with the above by Agassiz and Eichwald, are too imperfect for determination.

Form. & Loc. Upper Old Red Sandstone: Perthshire and Elgin.

P. 3284. Imperfect mandibular ramus in a slab of matrix filled with scales of *Holoptychius nobilissimus*; Clashbennie, Perthshire. *Enniskillen Coll.*

Sauripterus anglicus, sp. nov.

[Plate XVI. figs. 4–6.]

Type. Scales and tooth; British Museum.

A smaller species than the preceding, known only by scales and a detached laniary tooth. The tooth straight and regularly tapering, moderately compressed. Scales robust, the exposed portion ornamented with coarse, sparsely and irregularly arranged tubercles.

Form. & Loc. Upper Old Red Sandstone: Shropshire.

P. 200. Type specimen, being a slab of sandstone with about twelve scales and an imperfect tooth, one of the former and the latter shown, of the natural size, in Pl. XVI. figs. 4, 6; Farlow, Shropshire. *Weaver-Jones Coll.*

P. 201. Impression of tooth; Farlow. *Weaver-Jones Coll.*

P. 200 a. Group of large, partially tuberculated scales; Farlow. *Weaver-Jones Coll.*

P. 200 b. Still larger scale, with few tuberculations, shown of two-thirds the natural size in Pl. XVI. fig. 5; Farlow. *Weaver-Jones Coll.*

A hollow conical tooth from the Lower Carboniferous Limestone of Armagh, compared with *Rhizodus* and *Dendrodus* by M'Coy, is named *Colonodus longidens*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 5. The original specimen is in the Museum of the Geological Society, and is very doubtfully determined (J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. 1883, p. 523, pl. lxiii. fig. 6).

Another tooth from the Productus-Limestone of the Salt Range, India, perhaps referable to the Rhizodontidæ, is named *Sigmodus dubius*, W. Waagen, Palæont. Ind. [13] vol. i. (1879), p. 10, pl. i. fig. 7.

Family OSTEOLEPIDÆ.

Body fusiform, robust, elongated, and somewhat depressed, with rhomboidal scales, slightly overlapping, and covered externally with a more or less continuous layer of ganoine. Head and opercular apparatus with well-developed membrane-bones; parietals large and separate; frontals separate, or fused together and with the adjoining elements, in which case a median frontal foramen is conspicuous; orbits far forwards; interoperculum absent; jugular plates comprising one large pair, flanked on either side by a lateral series, and with or without a small azygous element in front. Dentary bone of mandible fused with well-developed infradentaries in the same plane, and forming a thin vertical lamina; an inner series of few large, narrow, shuttle-shaped bones, also fused with the dentary, and each supporting a "laniary" tooth; a pair of similar teeth on the roof of the mouth, but the marginal upper dentition feeble. Teeth conical, with a pulp-cavity, of which the walls are not folded, except quite at the base. Pectoral and pelvic fins obtusely lobate; two remote dorsal fins, the first nearly opposite or directly opposite to the pelvic pair; anal fin single; caudal fin diphycercal or heterocercal.

In the four typical genera of this family some of the anterior rays of each of the fins are relatively robust and covered with ganoine. This appearance is due, according to Pander, to the investment of the rays with true scales.

Synopsis of Genera.

I. Scales smooth and punctate.
- A pineal foramen; dorsal fins alternating with pelvic and anal; tail heterocercal .. *Osteolepis* (p. 368).
- A pineal foramen; dorsal fins opposed to pelvic and anal; tail heterocercal..... *Thursius* (p. 373).
- A pineal foramen; dorsal fins opposed to pelvic and anal; tail almost diphycercal and caudal fin rhomboidal ..... *Diplopterus* (p. 375).
- No pineal foramen; dorsal fins opposed to pelvic and anal; tail almost heterocercal .. *Megalichthys* (p. 378).

II. Scales sculptured.
- Anterior dorsal fin opposed to pelvic pair; tail diphycercal..... *Glyptopomus* (p. 389).

Genus **OSTEOLEPIS,** Valenciennes.

[Trans. Geol. Soc. [2] vol. iii. 1829, p. 144.]

Syn. *Pleiopterus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. 1835, p. 113.
Tripterus, F. M'Coy (*non* Quoy & Gaimard, 1824), Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 306.
Triplopterus, F. M'Coy, Brit. Palæoz. Foss. 1855, p. 589.

Cranial roof-bones in advance of the parietals usually fused into a continuous shield, with a median frontal foramen; an anterior median jugular plate present. Teeth rounded in transverse section. Ossified ring-shaped vertebræ in the abdominal region. First dorsal fin in advance of the pelvic pair, and the second dorsal opposed to the space between the pelvics and the anal. Tail strongly heterocercal; caudal fin obliquely truncated posteriorly. Scales smooth, punctate.

The most elaborate description of this genus is that of C. H. Pander (Saurodipt., Dendrodont. &c. devon. Syst. 1860). Good figures of the head had previously been published by Hugh Miller, "Footprints of the Creator" (1849), p. 51, figs. 12–15.

Osteolepis macrolepidotus, Agassiz.

[Plate XIII. fig. 1.]

(?) 1829. *Osteolepis macrolepidotus*, A. Valenciennes, Trans. Geol. Soc. [2] vol. iii. p. 144.
1835. *Osteolepis macrolepidotus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 119, pl. ii. *b*. figs. 1–4, pl. ii. *c*. figs. 5, 6.
1835. *Osteolepis microlepidotus*, L. Agassiz, *ibid.* p. 121, pl. ii. *c*. figs. 1–4.
1835. *Osteolepis arenatus*, L. Agassiz, *ibid.* p. 122, pl. ii. *d*. figs. 1–4. [British Museum.]
1841. *Osteolepis*, H. Miller, Old Red Sandstone, p. 72, pl. iv.
1844. *Osteolepis major*, L. Agassiz, Poiss. Foss. V. G. R. pp. 49, 51, pl. xix. figs. 1–3. [British Museum.]
1848. *Osteolepis brevis*; F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 305. [Woodwardian Museum, Cambridge.]
1848. *Tripterus pollexfeni*, F. M'Coy, *ibid.* p. 306. [Caudal region; Woodwardian Museum.]
1855. *Osteolepis arenatus*, *O. macrolepidotus*, *O. major*, and *O. microlepidotus*, F. M'Coy, Brit. Palæoz. Foss. pp. 587, 588.
1855. *Osteolepis brevis*, F. M'Coy, *ibid.* p. 587, pl. ii. D. fig. 4.
1855. *Triplopterus pollexfeni*, F. M'Coy, *ibid.* p. 589, pl. ii. D. fig. 5.
1860. *Osteolepis macrolepidotus*, C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. pp. 2 (in part), 7, pl. ii. figs. 2, 6–9, pl. iii. figs.

1–10, 15–21, pl. v. figs. 1–11 (probably in part *Thursius macrolepidotus*).

1888. *Osteolepis macrolepidotus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 515.

1890. *Osteolepis macrolepidotus*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 484.

Type. Imperfect fishes; *olim* T. S. Traill Collection.

The type species, attaining a maximum length of about 0·3. Head with opercular apparatus contained about four and a half times in the total length; parietal region about two thirds as long as the fronto-ethmoidal; jaws much elongated. Pelvic fins situated about halfway between the hinder margin of the operculum and the extremity of the tail; dorsal fins higher than long, separated by an interspace equal to twice the length of the base of the second dorsal, which is somewhat larger than the first dorsal and similar to the anal. Scales large.

Form. & Loc. Lower Old Red Sandstone: Orkney, Caithness, Ross-shire, Cromarty, Nairnshire, and Banffshire [1].

(i.) Orkney Isles (typical *O. macrolepidotus*).

P. 817. Small fish, 0·17 in length, showing the fins; Belyacreugh. *Egerton Coll.*

P. 3300–1. Three similar specimens, the third exhibiting small, slender, well-spaced teeth in the mandible. *Enniskillen Coll.*

P. 4604, P. 4606. Four imperfect specimens, one wanting the tail. *Enniskillen Coll.*

41136. Specimen displaying the large scales of the abdominal region. *Purchased*, 1868.

39195–96. Fish equal in size to the preceding, exhibiting the ventral aspect, and a smaller, very imperfect specimen, lateral aspect; Skaill. *Purchased*, 1865.

36185. Small fish, showing fins, mostly obscure. *Purchased*, 1861.

39253. Small crushed specimen (*O. brevis*, M'Coy); Stromness. *Purchased*, 1865.

36182–83. Similar fish, obscurely preserved, in counterpart. *Purchased*, 1861.

[1] Scales from the Devonian of St. Petersburg are doubtfully referred to the so-called *O. major* by Agassiz, Poiss. Foss. V. G. R. (1845), p. 138, pl. xxviii. *a*. fig. A, pl. xxxi. *a*. figs. 8–13. Other fragments of bones and scales from the Devonian of Russia are also ascribed to this species by E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1552.

(ii.) Cromarty.

P. 6082. Remains of a large fish, wanting the extremity of the tail. *Presented by F. Harford, Esq.*, 1889.

P. 4605. Similar, but more imperfect fish, showing the lobation of the pectoral fin. *Enniskillen Coll.*

P. 5065. Fragments of head and scales.
Presented by J. E. Lee, Esq., 1885.

19066, 19070–71. Three very imperfect specimens, the first in counterpart, the second with a lobate pectoral fin, the third showing the inferior aspect of a large head, with scattered scales. *Purchased*, 1845.

(iii.) Lethen Bar.

50103. Large fish, in counterpart, showing portions of all the fins, the lobate pectorals being especially well preserved.
Purchased, 1879.

49181. A much broken specimen, 0·3 in length, in counterpart, showing the fins. The fossil is drawn, of two-thirds the natural size, in Pl. XIII. fig. 1, and exhibits the lobation both of the pectoral (*pct.*) and pelvic (*plv.*) fins. Parts of the median fins are also well preserved; and the series of azygous dorsal ridge-scales is conspicuous in the anterior abdominal region. *Purchased*, 1878.

P. 6083 a–b. Remains of a large fish showing traces of vertebræ in the abdominal region; also a smaller individual, vertically crushed. *Presented by F. Harford, Esq.*, 1889.

49192. A smaller fish showing traces of the vertebræ in the abdominal region, the pelvic and median fins.
Purchased, 1878.

21547. Two imperfect small specimens, in counterpart; also a somewhat larger fish, showing the lobation of the paired fins. *Presented by Norman McLeod, Esq.*, 1847.

20790. Small fish exhibiting the attenuation of the caudal lobe and the lobation of the pelvic fins.
Presented by Colonel Sir Proby T. Cautley, K.C.B., and — Gordon, Esq., 1847.

P. 814. Two small specimens, the first showing the head, pectoral fins, and part of the abdominal region, the second exhibiting all the fins but wanting the head. *Egerton Coll.*

(iv.) Tynet Burn.

P. 3298. Type specimen of *Osteolepis major*. *Enniskillen Coll.*

P. 815. Two somewhat larger, imperfect fishes, the second wanting the extremity of the tail. *Egerton Coll.*

35782. Caudal region of a similar fish. *Purchased*, 1860.

37385. Remains of the head, squamation, and fins of a large individual. *Purchased*, 1863.

(v.) Gamrie.

28503–4. Type specimens of *Osteolepis arenata*, the second figured by Agassiz, Poiss. Foss. vol. ii. pl. ii. *d.* fig. 1, the counterpart of the first figured, *ibid.* pl. ii. *d.* fig. 3.
Presented by Sir Roderick I. Murchison, K.C.B., 1853.

47871. Small specimen, wanting the first dorsal fin.
Purchased, 1877.

P. 3297. Imperfect small specimen. *Enniskillen Coll.*

Osteolepis microlepidotus, Pander.

(?) 1829. *Osteolepis microlepidotus*, A. Valenciennes, Trans. Geol. Soc. [2] vol. iii. p. 144.
1860. *Osteolepis microlepidotus*, C. H. Pander (*non* Agassiz), Saurodipt., Dendrodont. &c. devon. Syst. p. 10, and *passim*, pl. i. figs. 1–6, 8–10, pl. ii. figs. 1, 3–5, 10–14.
1888. *Osteolepis microlepidotus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 516.
1890. *Osteolepis microlepidotus*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 484.

Type. Imperfect fishes; Imperial Academy of Sciences, St. Petersburg.

A small species, attaining a maximum length of about 0·15, and differing from *O. macrolepidotus* in the relatively broader form of the cranial shield and the less acute angle of the V-shaped impression of the sensory canal behind the pineal foramen.

Form. & Loc. Lower Old Red Sandstone: Caithness.

33144–47. Four imperfect specimens; Thurso. *Purchased*, 1857.

33158–62. Four imperfect specimens, the first in counterpart; Thurso. *Purchased*, 1857.

39189. Head-bones and greater portion of squamation; Thurso. *Bowerbank Coll.*

42456. Two imperfect specimens on one slab; Stone Gun. *Peach Coll.*

42468. Imperfect large fish; Thurso. *Peach Coll.*

P. 5489. Similar specimen, dorsal aspect, showing head and opercular bones; Thurso. *Purchased.*

49665–67. Three small specimens, showing the position of the fins; Holburn Head, near Thurso. *Purchased*, 1879.

P. 820. Two small specimens; Thurso. *Egerton Coll.*

P. 819. Head and anterior scales, labelled in Hugh Miller's handwriting, thus: "First specimen I laid open on visiting Wieland-burn, near Thurso, July 1846. . . This minute species of *Osteolepis*, varying from three to four inches in length, is very abundant at Wieland." *Egerton Coll.*

P. 3299. Portions of small fish; Thurso. *Enniskillen Coll.*

P. 6081. Two specimens, the smaller displaying the trunk and portions of fins, the larger showing parts of the head and squamation; Thurso.
Presented by F. Harford, Esq., 1889.

The supposed species from Russia described as follows are based upon insufficient material:—

Osteolepis fischeri, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1554, pl. lvii. fig. 15; C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. (1860), p. 7: *Megalichthys fischeri*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. (1844), p. 832, and vol. xix. (1846), pt. ii. p. 309, pl. x. fig. 34.—Devonian; Marjina, R. Slawjanka. [Frontal region of skull; University of St. Petersburg.]

Osteolepis intermedia, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. (1844), p. 831, and *ibid.* vol. xix. (1846), pt. ii. p. 308, pl. x. figs. 30, 31, and Leth. Rossica, vol. i. (1860), p. 1553, pl. lvii. fig. 10; L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 155.—Devonian; Marjina, and Borowitschi, R. Prikscha. [Scale; University of St. Petersburg.]

Osteolepis nana, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. (1844), p. 831, and *ibid.* vol. xix. (1846), pt. ii. p. 308, and Leth. Rossica, vol. i. (1860), p. 1555, pl. lvii. fig. 9; L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 155; C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. (1860), p. 7.—Devonian; Marjina. [Mandibular ramus; University of St. Petersburg. Scales from L. Carboniferous Limestone of Podmokloyé, Govt. Toula, also doubtfully ascribed to this species.]

Osteolepis tscherskyi, J. V. Rohon, Mém. Soc. Acad. Imp. Sci. St. Pétersbourg, [7] vol. xxxvi. no. 13 (1889), p. 13, pl. ii. figs. 32–35, 39, 41.—Devonian; Valley of Kisil-kul, 50 versts W. of Minusinsk, Govt. of Tomsk, Siberia. [Scales, &c.; Imperial Academy of Sciences, St. Petersburg.]

Genus **THURSIUS**, Traquair.

[Geol. Mag. [3] vol. v. 1888, p. 516.]

Head as in *Osteolepis* and *Diplopterus*. Dorsal fins opposed to the pelvic pair and the anal fin, respectively. Tail strongly heterocercal; caudal fin obliquely truncated posteriorly. Scales smooth and punctate.

Thursius macrolepidotus (Sedgwick & Murchison).

1829. *Dipterus macrolepidotus*, Sedgwick & Murchison, Trans. Geol. Soc. [2] vol. iii. p. 143, pl. xvi. fig. 2 (? figs. 4, 5).

1835. *Dipterus macrolepidotus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 115, pl. ii. fig. 4.

1855. *Diplopterax macrolepidotus*, F. M'Coy, Brit. Palæoz. Foss. p. 587 (in part).

(?) 1860. *Osteolepis*, C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. p. 9, pls. i.–iii. (in part).

1888. *Thursius macrolepidotus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 516.

Type. Small fish; Mus. Geological Society of London.

The type species, attaining a maximum length of about 0·25. Head with opercular apparatus occupying one-fifth of the total length; jaws much elongated; operculum deeper than broad, suboperculum smaller and broader than deep. Pelvic fins situated about halfway between the hinder margin of the operculum and the extremity of the tail; first dorsal fin much smaller than the

second, the latter deeper than long and similar to the opposing anal. Scales of moderate size.

Form. & Loc. Lower Old Red Sandstone: Caithness.

34990, 41359. Large specimen, in counterpart, showing the head and abdominal region from above, and the tail from the lateral aspect; Thurso. Many of the bones of the head are distinct and appear as in *Osteolepis* and *Diplopterus*. *Purchased*, 1860, 1869.

42462. Small, imperfectly preserved fish, wanting head; Sandside, Reay. *Peach Coll.*

42410–11, 42450, 42458–59, 42461, 42463–64, 42466. Seven small fishes and the caudal region of two others, of the form doubtfully assigned to this species by R. H. Traquair. Geol. Mag. [3] vol. v. p. 516; South Head, Wick. *Peach Coll.*

42437, 42439. Somewhat larger imperfect specimen, in counterpart; South Head. *Peach Coll.*

Thursius pholidotus, Traquair.

[Plate XIII. figs. 2, 3.]

1888. *Thursius pholidotus*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 516.

Type. Imperfect fish; Edinburgh Museum.

A species attaining a somewhat larger size than the type, and distinguished by the relatively very large proportions of the scales, and the comparative shortness and stoutness of the jaws.

Form. & Loc. Lower Old Red Sandstone: Caithness.

33173. Impression of head and opercular apparatus, and anterior scales; Holburn Head, near Thurso. *Purchased*, 1857.

41361. Imperfect head and trunk, 0·22 in length, wanting the pectoral fins. The hinder half of the fossil is drawn, of the natural size, in Pl. XIII. fig. 2, and the fins are indicated by the lettering; the head and abdominal region are much crushed and broken, and the former is exposed from beneath. *Purchased*, 1869.

49664. Much crushed and broken individual, 0·19 in length, in counterpart, showing portions of the fins; Holburn Head.

The attenuated caudal lobe is distinctly exhibited, and is fringed above by a series of short fin-rays.

Purchased, 1879.

33140. Trunk with pelvic, dorsal, and anal fins, and the base of the caudal; Thurso. The specimen is shown, of the natural size, in Pl. XIII. fig. 3, and the fins indicated by the lettering. Adjoining each dorsal fin is a very large, antero-posteriorly elongated ridge-scale.

Purchased, 1857.

42440. Imperfect head and trunk, wanting the extremity of the tail and the anal fin; South Head, Wick. Large conical teeth, simple in section, are shown in the jaws; and the lobation of the paired fins is distinct. *Peach Coll.*

Genus **DIPLOPTERUS**, Agassiz[1].

[Poiss. Foss. vol. ii. pt. i. 1835, p. 113.]

Cranial roof-bones in advance of the parietals fused into a continuous shield, with a median frontal foramen; an anterior azygous jugular plate present. Teeth rounded in transverse section. Dorsal fins opposed to the pelvic pair and the anal respectively. Tail almost diphycercal; caudal fin unsymmetrically rhomboidal, the upper lobe somewhat smaller than the lower. Scales smooth and punctate.

Diplopterus agassizi, Traill.

1841. *Diplopterus agassis*, T. S. Traill, Trans. Roy. Soc. Edinb. vol. xv. p. 89.

1844. *Diplopterus macrocephalus*, L. Agassiz, Poiss. Foss. V. G. R. p. 54, pls. xvi., xvii. [British Museum and Forres Museum.]

1844. *Diplopterus affinis*, L. Agassiz, *ibid.* pp. 55, 138, pl. xxxi. *a*. fig. 27.

1844. *Diplopterus borealis*, L. Agassiz, *ibid.* p. 55, pl. xviii. fig. 1 (? fig. 2). [*Olim* T. S. Traill Collection.]

1848. *Diplopterus gracilis*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 305. [Woodwardian Museum, Cambridge.]

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[1] This generic name is preoccupied (Latreille, 1817, and Boie, 1826), and M'Coy accordingly proposed the slightly modified, though essentially identical, form *Diplopterax*. As, however, the fish in question has been universally quoted for fifty years under the name of *Diplopterus*, we are unwilling to suggest a change which would necessitate future ichthyologists adopting a dual nomenclature.

1848. *Gyroptychius diplopteroides*, F. M'Coy, *ibid.* p. 309. [Woodwardian Museum.]
1849. *Diplopterus*, H. Miller, Footprints of the Creator, p. 57, woodc. figs. 16, 17.
1855. *Diplopterax affinis* and *D. agassizii*, F. M'Coy, Brit. Palæoz. Foss. p. 586.
1855. *Diplopterax gracilis*, F. M'Coy, *ibid.* p. 586, pl. ii. c. fig. 1.
1855. *Diplopterax macrolepidotus*, F. M'Coy, *ibid.* p. 587 (in part).
1855. *Gyroptychius diplopteroides*, F. M'Coy, *ibid.* p. 597, pl. ii. c. fig. 3.
1860. *Diplopterax borealis*, C. H. Pander, Saurodipt., Dendrodont. &c. devon. Syst. p. 23, pl. iii. figs. 22–27, pl. iv.
1888. *Diplopterus agassizii*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 516.
1890. *Diplopterus agassizii*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 484, woodc. fig. 3.

Type. Imperfect fish; *olim* T. S. Traill Collection.

The type species, attaining a large size, sometimes measuring 0·5 in length. Head with opercular apparatus occupying somewhat less than one quarter of the total length; operculum deeper than broad, suboperculum smaller and broader than deep. Pelvic fins situated far behind the middle point of the fish; first dorsal fin much smaller than the second, the latter deeper than long and similar in all respects to the opposing anal; caudal fin obtusely pointed posteriorly, the origin of its upper lobe precisely opposite to that of the lower, and the distance from this point to the origin of the first dorsal greater than the total length of the fin. Scales relatively large.

Form. & Loc. Lower Old Red Sandstone: Orkney, Caithness, Nairnshire, and Banffshire [1].

(i.) Orkney (typical *D. agassizi*).

P. 183. Large well-preserved specimen, in counterpart, 0·42 in length, wanting the dorsal fins and showing only portions of the pelvics and anal. *Purchased*, 1881.

P. 3294–a. Two smaller specimens, showing portions of all the fins; Belyacreugh. *Enniskillen Coll.*

29252 a. Fish 0·29 in length, displaying the fins, but with imperfect head. *Purchased.*

P 821. Fronto-ethmoidal portion of cranial shield. *Egerton Coll.*

[1] The so-called *Diplopterus macrocephalus* is also supposed to be represented by fragments from the Russian Devonian by L. Agassiz, Poiss. Foss. V. G. R. (1845), p. 138, pl. xxxi. *a.* figs. 1–7, and E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1556, pl. lvi. fig. 5.

39183. Caudal region and hinder half of abdominal region of a similar fish. *Purchased*, 1865.

P. 831. Portion of squamation of a very large individual, showing the inner rib of the flank-scales. *Egerton Coll.*

(ii.) Caithness.

P. 6283. Imperfect head and trunk, 0·32 in length.

P. 821 a. Plaster cast of cranial shield figured in Miller's 'Footprints,' p. 58, fig. 17; Thurso. *Egerton Coll.*

33164, 33168. Two examples of fronto-ethmoidal shield; Thurso. *Purchased*, 1857.

33171. Mandibular ramus; Holburn Head. *Purchased*, 1857.

(iii.) Lethen Bar (*D. macrocephalus*).

P. 551. Counterpart of one of the type specimens of *D. macrocephalus*, figured by Agassiz, *op. cit.* pl. xvi. fig. 3. *Egerton Coll.*

50101. Greater portion of a fine large specimen, in counterpart, showing the remains of two very large teeth in the mandible within the outer small series. The lobation of the pelvic fins and the form of the caudal fin are also well displayed. *Purchased*, 1879.

(iv.) Tynet Burn.

36008. Imperfectly preserved fish, 0·39 in length. *Purchased*, 1861.

43012. Smaller fish, showing scattered bones of head and opercular apparatus. *Purchased*, 1871.

43280. Much crushed similar fish, showing portions of all fins except the pectorals. *Purchased*, 1871.

36180. Tail of small fish, with median fins. *Purchased*, 1861.

(v.) Gamrie (*D. affinis*).

P. 4048. Vertically crushed large specimen, in counterpart, about 0·5 in length. Several bones of the head and opercular apparatus are displayed, and there are more or less well-preserved remains of all the fins. *Purchased*, 1883.

28863. Remains of fish, 0·27 in length, ventral aspect.
Purchased, 1854.

P. 827, P. 3293. Crushed trunk of fish, wanting head and paired fins. *Egerton & Enniskillen Colls.*

P. 827 a, P. 3293 a. Portions of head and anterior scales of a large individual: a close uniform series of conical teeth is seen in the mandible. *Egerton & Enniskillen Colls.*

Under the preoccupied generic name of *Gyrolepis*, and with the specific name of *G. posnaniensis*, scales much resembling those of the foregoing genera, from Lower Palæozoic boulders near Meseritz, Silesia, are described by G. Kade, Programm k. Realschule zu Meseritz, 1858, pp. 17, 18, figs. 8–10.

Genus **MEGALICHTHYS**, Agassiz.

[Poiss. Foss. vol. ii. pt. ii. 1844, pp. 89, 154.]

Syn. *Centrodus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 3, and *ibid.* vol. iii. 1849, p. 140.
Parabatrachus, R. Owen, Quart. Journ. Geol. Soc. vol. ix. 1853, p. 67.
Rhomboptychius, J. Young (*ex* Huxley, MS.), Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 604.
Ganolodus, R. Owen, Trans. Odontol. Soc. vol. v. 1867, p. 354 (in part).
Ectosteorhachis, E. D. Cope, Proc. Amer. Phil. Soc. vol. xix. 1880, p. 56.

Cranial roof-bones in advance of the parietals rarely fused into a continuous shield, without a median frontal foramen; an anterior azygous jugular plate present. Teeth rounded in transverse section. Ossified vertebræ in the form of narrow rings. First dorsal fin nearly opposite to the pelvic pair, and the second dorsal opposed to the anal. Tail intermediate between the diphycercal and heterocercal stages. Scales more or less smooth and punctate.

Megalichthys hibberti, Agassiz.

[Plate XIII. fig. 4.]

1835. *Ichthyolithus clackmannensis*, J. Fleming, Edinb. New Phil. Mag. vol. xix. p. 314, pl. iv. figs. 1–3. [Portions of Fish; Edinburgh Museum.]
1844. *Megalichthys hibberti*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 90, pls. lxiii., lxiii. *a*., lxiv.

1844. *Megalichthys maxillaris*, L. Agassiz, *ibid.* p. 96. [Head; Leeds Museum.]
1844. *Megalichthys hibberti*, R. Garner, Nat. Hist. Staffordsh. p. 446, pl. E. fig. 10.
1848. *Centrodus striatulus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 4. [Tooth; Woodwardian Museum, Cambridge.]
1849. *Megalichthys hibberti*, W. C. Williamson, Phil. Trans. p. 450, pl. xli. fig. 15, pl. xlii. figs. 16–19.
1853. *Parabatrachus colei*, R. Owen, Quart. Journ. Geol. Soc. vol. ix. p. 67, pl. ii. fig. 1. [Maxilla; British Museum.]
1855. *Centrodus striatulus*, F. M'Coy, *ibid.* p. 611, pl. iii. G. fig. 1.
1861. *Megalichthys hibberti*, J. W. Salter (*ex* Egerton, MS.), Foss. S. Welsh Coalfield (Mem. Geol. Surv.—Iron Ores Gt. Britain, pt. iii.), p. 224, pl. i. fig. 16.
1866. *Megalichthys*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 607.
1867. *Ganolodus sicula*, R. Owen, Trans. Odontol. Soc. vol. v. p. 354, pl. vii. (assigned to *Megalichthys* by Hancock and Atthey, Nat. Hist. Trans. Northumb. and Durham, vol. iii. 1870, p. 90). [Micro. section of tooth; British Museum.]
1868. *Megalichthys*, J. Young, Proc. Nat. Hist. Soc. Glasgow, vol. i. p. 174, pl. i. figs. 1–3.
1873. *Megalichthys*, T. P. Barkas, Coal-Meas. Palæont. p. 25, figs. 70–82.
1875. *Megalichthys hibberti*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 227, figs. 10, 14.
1876. *Megalichthys hibberti*, W. J. Barkas, Monthly Rev. Dental Surgery, vol. iv. pp. 59, 197, 251, figs. lxxi.–lxxix.
1876. *Megalichthys tuberculatus*, W. J. Barkas, *ibid.* p. 61. [Decorticated bones.]
1878. *Megalichthys hibberti*, R. Etheridge, jun., Geol. Mag. [2] vol. v. p. 269.
1884. *Megalichthys hibberti*, L. C. Miall, Quart. Journ. Geol. Soc. vol. xl. p. 347, woodc. figs. 1–4, 6.
1884. *Megalichthys hibberti*, R. H. Traquair, Proc. Roy. Phys. Soc. Edinb. vol. viii. p. 72, and Geol. Mag. [3] vol. i. p. 118.
1885. *Megalichthys hibberti*, L. C. Miall, Description of the Remains of *Megalichthys* in the Leeds Museum.
1890. *Megalichthys hibberti*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 162, pl. ii. figs. 4, 23.

Type. Head and anterior scales; Leeds Museum.

The type species, attaining a length of about 1·5. Head with opercular apparatus occupying one-fifth of the total length; parietal region of cranium longer than the fronto-ethmoidal; length of maxilla about three times as great as the depth of the posterior expansion; mandible long and slender, not less than five times as

long as deep; teeth with fine superficial vertical striæ; operculum nearly as broad as deep; each of the pair of jugular plates about two and a half times as long as broad, abruptly truncated posteriorly. Ring-vertebræ relatively broad. Ganoine smooth and uniformly punctate.

This is also the type species of the so-called *Centrodus*, *Parabatrachus*, and *Ganolodus*.

Form. & Loc. Coal-Measures: all Coal-fields of England, Wales, and Scotland (? and Ireland).

P. 6284. Fish 0·93 in length, wanting the extremity of the tail; Coalbrookdale. The specimen shows the ventral aspect, and of fins exhibits only portions of the pectorals, which are distinctly obtusely lobate. *Purchased.*

P. 5231. Head and scales of anterior portion of trunk; Dudley. The cranial roof-bones, though broken, are well shown, and portions of the mandibular rami and opercular apparatus are distinct. *Purchased*, 1886.

P. 5232. Similar specimen, of larger size; Dudley. *Purchased*, 1886.

P. 800. Remains of a small head; locality unknown. *Egerton Coll.*

P. 805. Parietal bones and the squamosal and postfrontal elements of the right side, most of the superficial ganoine-layer removed; locality unknown. *Egerton Coll.*

21421. Fronto-ethmoidal region of skull, somewhat crushed and obscured by matrix; Carluke. *Purchased*, 1847.

P. 3306. Similar specimen; Carluke. *Enniskillen Coll.*

P. 3307. Similar specimen; Longton, Staffordshire. *Enniskillen Coll.*

39164. Fragment of premaxilla and dentary; Coalbrookdale. *Bowerbank Coll.*

P. 3312. Left maxilla, with portions of other bones and scales, wanting most of the superficial ganoine; Dalkeith. *Enniskillen Coll.*

P. 3313. Fragmentary maxilla, associated with scales; Dalkeith. *Enniskillen Coll.*

29673. Imperfect right maxilla, inner aspect, associated with a scale, forming the type specimen of *Parabatrachus colei*, Owen, *loc. cit.*, and assigned to *Megalichthys hibberti* by J. Young, *loc. cit.*, 1868 ; Carluke. *Enniskillen Coll.*

21421 a. Portion of maxilla showing teeth ; Carluke. *Purchased*, 1847.

P. 3309. Group of head-bones, including mandibular rami ; Carluke. *Enniskillen Coll.*

P. 3304–5, P. 3308. Two large mandibular rami, about 0·23 in length, and two fragments, showing some of the teeth ; Carluke. *Enniskillen Coll.*

21222 g. Portion of large mandibular ramus, associated with scales ; Carluke. *Purchased*, 1847.

P. 798. Right mandibular ramus, about 0·2 in length ; Low Main Seam, Newsham, near Newcastle-upon-Tyne. *Egerton Coll.*

P. 4591. Imperfect small mandibular ramus ; Lowmoor, Yorkshire. *Enniskillen Coll.*

P. 3310. Anterior half of small left mandibular ramus, with well-preserved teeth ; Knowles Ironstone Shale, Fenton, N. Staffordshire. *Enniskillen Coll.*

49611. Small right mandibular ramus, associated with scales and portions of bones ; Staffordshire. *Purchased*, 1878.

P. 800 a, P. 806. Four fragments of mandible ; locality unknown. *Egerton Coll.*

21975. Left mandibular ramus of young, measuring 0·048 in length, and about five times as long as deep ; Carluke. *Purchased*, 1848.

21423. Numerous detached teeth ; Carluke. *Purchased*, 1847.

P. 6243. Longitudinal section of tooth, prepared for microscopical examination, the type of *Ganolodus sicula*, Owen ; Newsham, near Newcastle-upon-Tyne. *Presented by Sir Richard Owen, K.C.B.*, 1890.

33299-a, b. Operculum wanting part of the hinder border, and a crushed and broken example of the same bone ; also an undetermined bone ; Carluke. *Purchased*, 1858.

21421 b, 21975 a, b. Lateral jugular, one of the principal jugulars associated with scales, and another slab of shale showing undetermined bones with scales and a vertebra; Carluke. *Purchased*, 1847–48.

21421 c, d. Two slabs of shale, showing well-preserved ring-vertebræ, with neural and hæmal arches, associated with scales; Carluke. *Purchased*, 1847.

P. 3326. Large ring-vertebræ associated with scales; Carluke. *Enniskillen Coll.*

P. 3327. Scales associated with a ring-vertebra; Dalkeith. *Enniskillen Coll.*

P. 3329. Three ring-vertebræ; Longton. *Enniskillen Coll.*

45858. Left clavicle, wanting most of the superficial ganoine; Newsham. *Purchased*, 1874.

P. 256 a. Portion of upper caudal lobe and fin; English Coal-Measures. *Presented by J. Wood-Mason, Esq.*, 1880.

P. 4471. Fragment of naturally-arranged squamation; Dalkeith. *Enniskillen Coll.*

20699, 21222 h. Scales; Carluke. *Purchased*, 1847.

P. 4472. Imperfect scales in Cannel Coal; Wigan. *Enniskillen Coll.*

41251 a. Scales; Upper Coal-Measures (*Spirorbis* Limestone), Ardwick, Manchester. *Purchased*, 1869.

P. 242. Group of scales; Knowles Ironstone Shale, Fenton, North Staffordshire. *Weaver-Jones Coll.*

P. 3328. Two groups of scales; Knowles Ironstone Shale, Fenton. *Enniskillen Coll.*

P. 807. Group of scales; Dudley. *Egerton Coll.*

P. 4090. Detached scales and teeth; Gubbin Ironstone Shale, Old Hill, near Stourbridge. *Presented by Horace Pearce, Esq.*, 1883.

P. 2286. Scales and miscellaneous remains; Carluke. *Presented by G. Griffiths, Esq.*, 1882.

38007. Imperfect small fish, probably young of *M. hibberti*, noticed by R. H. Traquair, Geol. Mag. [3] vol. i. (1884), p. 118;

Airdrie. The head and abdominal region are very imperfectly preserved, but the caudal region is well exhibited from the lateral aspect, and is shown, of the natural size, in Pl. XIII. fig. 4. Impressions of the opercular apparatus occur, and there are fragments of the pectoral fins; but the only other feature of interest in the anterior portion of the fish is the "decortication" of the scales, which consequently exhibit the characteristic ornamentation of the so-called *Rhomboptychius*. The removal of some of the scales upon the tail exposes a few of the vertebræ (*v.*), with their neural and hæmal arches; and impressions of several of the latter are distinct at the base of the caudal fin (*c*). In the front of each median fin there are large fulcral scales at the base, and a few of the anterior fin-rays are coated with ganoine; all the rays are broad, articulated, and closely arranged. The lobe of one of the pelvic fins (*plv.*) is distinct, and the dorsal fins (d_1, d_2) are opposed to this and the anal (*a*) respectively; the posterior portion of the caudal fin (*c*) is unfortunately missing. *Purchased*, 1864.

P. 3325. Imperfect fish, wanting fins, about 0·7 in length, doubtfully pertaining to this species; Castlecomer, Kilkenny, Ireland. Portions of some head and opercular bones and impressions of others are seen; and the left clavicle and infraclavicle occur, destitute of the superficial layer of ganoine. *Enniskillen Coll.*

P. 3325 a. Partly scattered squamation of a similar fish; Castlecomer. *Enniskillen Coll.*

P. 2292. Coprolite, with scales doubtfully of this species; Govan, near Glasgow. *Presented by George Griffiths, Esq.*, 1852.

Megalichthys coccolepis, Young.

[Plate XIII. fig. 5.]

1870. *Megalichthys coccolepis*, J. Young, Rep. Brit. Assoc. 1869, Trans. Sect. p. 102.

1875. *Megalichthys coccolepis*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 229.

1876. *Megalichthys coccolepis*, W. J. Barkas, Monthly Rev. Dental Surgery, vol. iv. p. 60.

1890. *Megalichthys coccolepis*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 165.

Type. Scales and head-bones; collection of James Thomson, Esq., Glasgow.

Proportions of bones and scales, so far as known, resembling those of the type species. Ganoine covered with numerous small, closely-arranged, blunt tuberculations.

Form. & Loc. Coal-Measures: Lanarkshire, Northumberland, and Staffordshire.

P. 4590. Left mandibular ramus, 0·135 in length, but imperfect anteriorly and exhibiting only the bases of the teeth; also an associated dermal plate and scale; Low Main Seam, Newsham, near Newcastle-upon-Tyne.

Enniskillen Coll.

P. 5494, P. 5137. Hinder portion of a similar mandibular ramus and a fragment; Newsham. Of the first specimen, a portion of the ornament is shown, five times the natural size, in Pl. XIII. fig. 5.

Presented by William Dinning, Esq., 1888.

Megalichthys intermedius, sp. nov.

1866. *Rhomboptychius*, J. Young (*ex* Huxley, MS.), Quart. Journ. Geol. Soc. vol. xxii. pp. 597, 604, woodc. figs. 1, 2. [Imperfect fish; Andersonian Museum, Glasgow.]

(?) 1870. *Megalichthys rugosus*, J. Young, Rep. Brit. Assoc. 1869, Trans. Sect. p. 102. [Specifically indeterminable decorticated bones; collection of James Thomson, Esq., Glasgow.]

1875. *Rhomboptychius*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 230, fig. 6.

(?) 1875. *Megalichthys rugosus*, J. Ward, *ibid.* p. 229.

1890. *Megalichthys rugosus*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 118.

1890. *Rhomboptychius*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 166, pl. ii. figs. 6, 24, pl. viii. fig. 9.

Type. Portions of head; British Museum.

A species attaining a somewhat larger size than the type. Mandible elongated, not less than five times as long as deep; posterior expansion of maxilla relatively deep; larger teeth smooth or finely striated, often transversely banded, and sometimes with one or two rings of slight, vertically elongated indentations. Each of the pair of jugular plates about two and a half times as long as broad, rounded or obliquely truncated posteriorly. Ring-vertebræ much more slender than in *M. hibberti*; superficial ganoine upon the

scales and head-bones apparently thinner than in the last-named species.

Though regarded by Young as the type of a distinct genus, *Rhomboptychius*, on account of the characters of the scales and teeth, the specimens mentioned below prove that no sufficient basis for the generic separation of this species from *Megalichthys* can yet be established.

Form. & Loc. Coal-Measures: South Scotland and North Staffordshire.

37320–21. Two slabs of shale exhibiting various bones and scales; Airdrie, Lanarkshire. The first specimen, which is to be regarded as the type, shows the left mandibular ramus and other portions of the jaws with teeth, the oral aspect of some of these bones being covered with numerous small, closely-arranged dental tubercles, as described by Young; the greater portion of the operculum is seen from the inner aspect, and several scales are preserved, showing not only fragments of the superficial ganoine-layer, but also, in some instances, a well-marked median rib on the inner side; a few of the characteristic slender ring-vertebræ also occur. The second specimen shows the pair of jugular plates and portions of jaws, with teeth, from the inner aspect; the larger teeth are transversely banded, and the external aspect of the bones is covered with ganoine. *Purchased*, 1863.

P. 3324. Jugular plate; Gubbin Ironstone Shale, Shelton, North Staffordshire. *Enniskillen Coll.*

37974–75. Two slabs with miscellaneous remains; Airdrie. *Purchased*, 1863.

P. 3303. Group of head-bones; Carluke. *Enniskillen Coll.*

P. 4465. Small slab with miscellaneous remains; Carluke. *Enniskillen Coll.*

P. 4802. Greater portion of right maxilla with teeth; Palace Craig Ironstone, Airdrie. *Armstrong Coll., transferred from Mus. Science & Art, Edinburgh*, 1884.

39248. Portion of maxilla; Airdrie. *Purchased*, 1865.

37973, 38010. Portions of two large mandibular rami showing the bases of teeth, one associated with detached scales; Airdrie. *Purchased*, 1863–64.

38556, 42037, 46023. Three fragments of mandible; Airdrie. *Purchased*, 1864, 1870, 1874.

P. 5179. Portion of mandibular ramus wanting the external layer of ganoine, displaying a portion of the series of small teeth, and three large inner teeth, of which the second (*i. e.* that upon the most anterior internal dentary bone) shows the indentations characteristic of "*Rhomboptychius*"; Deep Mine, Longton, North Staffordshire. This specimen is noticed by J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 167. *Purchased*, 1885.

P. 3311. Six large teeth; Deep Mine, Longton. *Enniskillen Coll.*

P. 249. Large, transversely-banded tooth; Knowles Ironstone, Fenton, North Staffordshire. *Weaver-Jones Coll.*

P. 793. Large transversely banded and indented tooth; Deep Mine, Longton. *Egerton Coll.*

P. 3279. Three ring-vertebræ; Longton. *Enniskillen Coll.*

40175, 42001. Scales and bone-fragments, the second group doubtfully of this species; Airdrie. *Purchased*, 1866, 1870.

46024–25. Group of small "decorticated" scales, and two associated scales of the lateral line; Airdrie. *Purchased*, 1874.

P. 361. "Decorticated" scales; Airdrie. *Purchased*, 1881.

P. 4801. Similar large scales; Airdrie Blackband, Carnbroe. *Armstrong Coll.—Transferred from Edinburgh Museum*, 1884.

P. 3314. Group of similar scales, a few showing the ganoine layer; Dalkeith. *Enniskillen Coll.*

P. 802–4. Three groups of similar scales, some showing the ganoine layer; locality unknown. *Egerton Coll.*

Megalichthys laticeps, Traquair.

1836. *Megalichthys*, S. Hibbert (in part), Trans. Roy. Soc. Edinb. vol. xiii. pl. xi. figs. 2–8.

(?) 1844. *Diplopterus robertsoni*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 162 (name only).

1884. *Megalichthys laticeps*, R. H. Traquair, Proc. Roy. Phys. Soc.

Edinb. vol. viii. p. 67, pl. iv., and Geol. Mag. [3] vol. i. p. 115, pl. v. figs. 1–6.

1890. *Megalichthys laticeps*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 389.

Type. Portions of fishes; Edinburgh Museum.

A comparatively small species. Parietal region of cranium broad, shorter than the fronto-ethmoidal region; length of maxilla more than four times as great as the depth of its posterior expansion; mandible more than four times as long as deep; each of the pair of jugular plates about two and a half times as long as broad, abruptly truncated posteriorly. Pelvic fins situated far behind the middle of the body. Ganoine smooth and uniformly punctate.

Form. & Loc. Calciferous Sandstones: Burdiehouse, near Edinburgh, and Burntisland, Fifeshire.

All the following specimens were obtained from the Burdiehouse Limestone.

P. 733–4. A series of fragments of fishes, one labelled *Megalichthys hibberti* in Agassiz's handwriting, and some showing well-preserved fins. *Egerton Coll.*

37380. Portion of right mandibular ramus showing dental tubercles on the splenial bone. *Purchased*, 1863.

14058, 15537. Scales. *Purchased.*

47720. Group of scales. *Presented by Dr. Lauder Lindsay*, 1876.

P. 4470. Two groups of scales, one labelled *Megalichthys hibberti* in Agassiz's handwriting. *Enniskillen Coll.*

Megalichthys pygmæus, Traquair.

1841. *Megalichthys hibberti* ("young"), E. W. Binney, Trans. Manchester Geol. Soc. vol. i. p. 163, pl. v. figs. 1, 2.

1844. *Diplopterus carbonarius*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 162 (name only). [Scales, &c.; British Museum.]

1879. *Megalichthys pygmæus*, R. H. Traquair, Mem. Geol. Surv. Scotland, Expl. to Sheet 31, p. 76 (name only).

1890. *Megalichthys pygmæus*, R. H. Traquair, in J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 164, pl. vi. figs. 7, 8.

Type. Mandibular ramus; Geological Survey of Scotland.

An imperfectly known species of very small size. Mandible three and a half times as long as deep; each of the pair of jugular plates also three and a half times as long as broad, pointed in front, rounded behind. Scales relatively thick, coarsely punctate.

It remains uncertain whether or not this is the immature form of *M. hibberti*.

Form. & Loc. Coal-Measures: Lanarkshire, Northumberland, Yorkshire, Derbyshire, and Staffordshire.

46811. Rostral portion of cranium; English Coal-Measures. *Cunnington Coll.*

P. 5138. Mandibular ramus, 0·011 in length; from shale accompanying Townley Seam, Wylam-on-Tyne. *Presented by William Dinning, Esq.*, 1886.

P. 828 b. Portion of similar mandibular ramus, noticed by Traquair, *loc. cit.* 1890, p. 164; Leeds. *Egerton Coll.*

P. 828 a, c, e. Fragment and two scales, the first labelled *Diplopterus carbonarius* by Agassiz; Leeds. *Egerton Coll.*

P. 3302. Fragments of head and scales; Leeds. *Enniskillen Coll.*

Species not represented in the Collection have also been partially defined under the following names:—

Megalichthys ciceronius: *Ectosteorhachis ciceronius*, E. D. Cope, Proc. Amer. Phil. Soc. vol. xx. (1883), p. 628.—Permian; Texas. [Imperfect cranium; collection of Prof. E. D. Cope, Philadelphia.]

Megalichthys lævis, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. (1890), p. 394.—Calciferous Sandstone; Straiton, near Edinburgh. [Imperfect fishes; Edinburgh Museum.]

Megalichthys nitidus: *Ectosteorhachis nitidus*, E. D. Cope, Proc. Amer. Phil. Soc. vol. xix. (1880), p. 56.—Permian; Texas. [Head and abdominal region, the type of *Ectosteorhachis*; collection of Prof. E. D. Cope.]

Detached scales indistinguishable from those of *Megalichthys hibberti* have also been discovered in the Coal-Measures of Ohio (J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. 1873, p. 343, pl. xl. fig. 3) and Nova Scotia (*Psammodus bretonensis*, J. F. Whiteaves, Canadian Naturalist, n. s., vol. x. 1881, p. 36). The error involved in the latter determination has been pointed out to the writer by Mr. J. F. Whiteaves, in the Museum of the Canadian Geological Survey, Ottawa, where the type specimen is preserved.

A doubtful scale from the Lower Permian of Kounová, Bohemia, is also named *Megalichthys nitens*, A. Fritsch, Fauna der Gaskohle, vol. ii. (1889), pl. lxxxviii. figs. 15, 16.

It seems probable that the following insufficiently characterized genera and species are founded upon scales of Osteolepidæ:—

Plintholepis retrorsa, H. Romanowsky, Bull. Soc. Imp. Nat. Moscou, vol. xxxvii. (1864), pt. ii. p. 169, pl. iv. fig. 37. —Carboniferous Limestone; Government of Toula.

Sporolepis pyriformis and *S. crassa*, H. Romanowsky, *ibid.* p. 169, pl. iv. figs. 38 *a*, *b*.—Ibid. [? Fulcral scales.]

Genus **GLYPTOPOMUS**, Agassiz.

[Poiss. Foss. V. G. R. 1844, p. 57.]

Syn. *Platygnathus*, L. Agassiz, *ibid.* p. 77 (in part).
Glyptolæmus, T. H. Huxley, in Anderson's Dura Den, 1859, p. 63.

Head-bones in advance of the parietals not fused into a continuous shield; frontals separate, with a median foramen; head-bones, operculum, and jugular plates ornamented with irregular reticulating rugæ or fused series of tubercles, apparently coated with a very thin layer of ganoine; no anterior median jugular plate. Anterior dorsal fin opposed to the pelvic pair and the posterior to the anal; tail diphycercal, with a rhomboidal caudal fin. Scales with broad overlapped border, externally ornamented with tubercles and reticulating rugæ of ganoine.

The characteristic external ornamentation of this genus seems to be due to the special development of the rugosities so characteristic of *Megalichthys* when the superficial ganoine is removed. Though ganoine is sometimes stated to be absent upon the dermal skeleton of *Glyptopomus*, the present writer is of opinion that an extremely thin layer occurs.

Glyptopomus minus, Agassiz.

1844–45. *Platygnathus minor*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 162 (name only), and Poiss. Foss. V. G. R., lettering of pl. xxvi.
1844. *Glyptopomus minor*, L. Agassiz, Poiss. Foss. V. G. R. p. 57.
1859. *Glyptopomus minor*, J. Anderson, Dura Den, p. 55, pl. ii.
1866. *Glyptopomus minor*, T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. xii. p. 4, pl. i. figs. 1, 3, 4.

Type. Imperfect head and trunk, dorsal aspect; British Museum.

The type species, attaining a length of about 0·4. Head with opercular apparatus contained about five times in the total length; jaws much elongated; principal jugular plates rapidly tapering and

acuminate in front, nearly two and a half times as long as their maximum breadth. Scales large and thick, covered with even rounded ridges forming a complete reticulation.

The finest known example of this fish, described by Huxley in 1866, is now in the Elgin Museum.

Form. & Loc. Upper Old Red Sandstone: Fifeshire and Elgin.

26118. Type specimen, described and figured by Agassiz and Anderson; Dura Den, Fifeshire. *Purchased*, 1851.

Glyptopomus sayrei, Newberry.

1878. *Glyptopomus sayrei*, J. S. Newberry, Ann. New York Acad. Sci. vol. i. p. 189.

1889. *Glyptopomus sayrei*, J. S. Newberry, Palæoz. Fishes N. America, p. 116, pl. xviii. fig. 1.

Type. Head, pectoral fins, and anterior abdominal region, ventral aspect; Lehigh University, Pennsylvania.

A species closely related to *G. minor*, known only by the type specimen. The "triangular accessory jugulars" of *G. minor* noted by Newberry are the infraclavicles, met with in all Crossopterygians sufficiently well preserved.

In this fossil the lateral jugular plates are shown, and it is suggested (*op. cit.* 1889, p. 118) that if such plates eventually prove to be absent in the typical *G. minor*, the fish may be regarded as representing a distinct genus, *Glyptognathus*.

Form. & Loc. Catskill Group: Susquehanna River, near mouth of Mehoopany River, Pennsylvania.

Not represented in the Collection.

Glyptopomus kinnairdi, Huxley.

1859. *Glyptolæmus kinnairdi*, T. H. Huxley, in Anderson's Dura Den, p. 63, pls. iii., iv.

1859. *Diplopterus dalgleisiensis*, J. Anderson, *ibid.* p. 71, pl. i. fig. 4. [Head; Museum of Practical Geology.]

1861. *Glyptolæmus kinnairdi*, T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 41, pls. i., ii.

1862. *Glyptolæmus*, J. Powrie, Quart. Journ. Geol. Soc. vol. xviii. p. 435.

(?) 1888. *Glyptolæmus kinnairdi*, M. Lohest, Ann. Soc. Géol. Belg. vol. xv. p. 158, pl. ix. figs. 6, 7. [Scales; M. Lohest Collection, Liége.]

1890. *Glyptolæmus kinnairdi*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, p. 85.

1890. *Glyptolæmus kinnairdi*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 389.

Type. Fishes; Museum of Practical Geology.

A very slender species, attaining a maximum length of about 0·4. Head with opercular apparatus more than twice as long as its maximum depth, comprised about five times in the total length. Parietal region long and narrow, exceeding the frontal region in length; jaws much elongated; principal jugular plates rapidly tapering and acuminate in front, three and a half times as long as their maximum breadth. Pelvic fins remote, arising midway between the pectorals and the extremity of the caudal. Scales relatively smaller than in *G. minor*, these and the head-bones ornamented with sharper, more irregularly developed reticulating rugæ than in the latter species.

This is the type species of the so-called *Glyptolæmus*.

Form. & Loc. Upper Old Red Sandstone: Fifeshire. (?) Upper Devonian: Belgium.

26117 a. Head and imperfect trunk, ventral aspect, showing a fragment of the left pectoral fin; Dura Den. The specimen is associated with the anterior half of the head of another individual, and remains of *Holoptychius*.
Purchased, 1851.

P. 6285. Fragment of trunk; Dura Den. *Enniskillen Coll.*

Family ONYCHODONTIDÆ.

Scales cycloidal, deeply overlapping. Head and opercular apparatus with well-developed membrane-bones. Dentary bone of mandible thin and deep, bearing a single close series of large conical teeth, flanked by an outer series of very minute teeth; an azygous scroll-like element occupying a groove in the dentaries at their symphysis. Teeth plicated only at the base, with a central cavity; dentary teeth tipped only, presymphysial teeth completely enveloped with enamel.

The single known genus of this family, *Onychodus*, has hitherto been found only in a fragmentary condition. The form and proportions of the trunk and fins thus await discovery.

Genus **ONYCHODUS**, Newberry.

[Bull. National Institute, 1857, p. 5.]

External bones and scales ornamented with tuberculations, more or less conical and radiately grooved. Clavicle triangular in shape, with relatively large inferior limb; infraclavicle without an elongated ascending process. Presymphysial bone very prominent, its teeth much larger than those of the dentary.

Onychodus sigmoides, Newberry.

1857. *Onychodus sigmoides*, J. S. Newberry, Bull. National Inst. p. 5.
1862. *Onychodus hopkinsi*, J. S. Newberry (*errore*), Amer. Journ. Sci. [2] vol. xxxiv. p. 77, woodc. fig. 3.
1873. *Onychodus sigmoides*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. p. 299, pl. xxvi. figs. 1–5, pl. xxvii. figs. 1, 2.
1889. *Onychodus sigmoides*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi.), p. 56, pl. xxxvi. figs. 1–4, pl. xxxvii. figs. 1–10.

Type. Portions of mandible; Columbia College, New York.

The type species of large size, the longest presymphysial teeth measuring 0·058 in length. Tuberculations upon scales conical and prominently sculptured, those upon the external bones rounder, somewhat smoother, and more numerous. Dentary teeth regular in size and shape throughout the greater part of the thickened oral border, each tumid in its basal half and tapering to the very slender enamelled apical portion; presymphysial teeth sigmoidally curved, stout, with a large central cavity, nearly regular in size, and loosely attached to the supporting bone.

Several detached bones of this species, in the Museum of Columbia College, New York, are figured by Newberry, *op. cit.*, 1889.

Form. & Loc. Corniferous Limestone (Lower Devonian): Ohio.

Not represented in the Collection.

Onychodus anglicus, A. S. Woodward.

[Plate XV. fig. 1.]

1888. *Onychodus anglicus*, A. S. Woodward, Geol. Mag. [3] vol. v. p. 500, woodc.

Type. Presymphysial bone; Oxford Museum.

A very small species, known only by the presymphysial bone, which is remarkably in-rolled in the form of a scroll at its inferior extremity. Presymphysial teeth tumid in the basal half, much

attenuated in the distal half, firmly fixed to the supporting bone, and with a relatively small internal cavity; the teeth diminishing rapidly in size downwards in the series.

Form. & Loc. Lower Old Red Sandstone: Herefordshire.

Fig. 52.

Onychodus anglicus, A. S. Woodw.—Presymphysial dentition, side view (partly in section), twice nat. size. [Oxford Museum.]

P. 6252. The inferior portion of a presymphysial bone, exhibited in vertical section in matrix, shown of twice the natural size in Pl. XV. fig. 1; Bush Pitch, Ledbury.

Presented by George H. Piper, Esq., 1890.

The following species are also known only by remains of the presymphysial dentition, of which there are no examples in the Collection:—

Onychodus arcticus, A. S. Woodward, Rep. Brit. Assoc. 1889, p. 585, and Geol. Mag. [3] vol. vi. (1889), p. 499.—Lower Devonian; Spitzbergen. [Royal State Museum, Stockholm.]

Onychodus hopkinsi, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873) p. 302, and Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 99.—Chemung Group (Upper Devonian); Delaware Co., New York.

Onychodus ortoni, J. S. Newberry, Palæoz. Fishes N. America (Mon. U.S. Geol. Surv. no. xvi. 1889), p. 71, pl. xix. fig. 1.—Huron Shale (Upper Devonian); Franklin Co., Ohio.

An undetermined species, as large as the type, also seems to be indicated by some robust, sigmoidally curved teeth from the Devonian of Gerolstein, Eifel, Germany, preserved in the Museum of Comparative Zoology, Cambridge, Mass., U.S.A.

Suborder III. *ACTINISTIA.*

Notochord persistent. Axonosts of each of the dorsal and anal fins fused into a single piece; a series of axonosts, equal in number to the supporting neural and hæmal spines, present in the caudal fin above and below, each axonost directly connected with a single dermal fin-ray. Axonost of pelvic fin on each side single, the right and left not fused together mesially.

Of this suborder only one family, that of the Cœlacanthidæ, is at present known.

Family CŒLACANTHIDÆ.

Body deeply and irregularly fusiform, with cycloidal, deeply-overlapping scales, more or less ornamented with ganoine. Branchiostegal apparatus consisting of an operculum on each side and a single pair of large jugular plates. Paired fins obtusely lobate. Two dorsal fins and a single anal; the anterior dorsal without baseosts, the posterior dorsal and the anal with baseosts, obtusely lobate. Axial skeleton extending to the extremity of the caudal fin, usually projecting and terminated by a small supplementary caudal fin. Air-bladder ossified.

As in many other primitive types of fishes, the arches and spines of the axial skeleton in this family are only superficially ossified, thus appearing, in the fossilized state, as if originally hollow. Such an appearance suggested the name of Cœlacanthidæ to Agassiz, who used the term in a wide and somewhat indefinite sense. The first scientific definition of the family was given by Huxley in 1861 and 1866.

The most satisfactory information concerning the osteology of the Cœlacanthidæ is afforded by remains from the Chalk of England and the Lithographic Stone of Bavaria. *Macropoma*, from the Chalk, is described in detail by Huxley [1], chiefly from specimens recorded below; while the genera of the Lithographic Stone are elucidated by Reis in a recently published memoir [2]. *Undina gulo*, from the English Lias, is also often well preserved, and a restoration of the skeleton is given in fig. 53, p. 412.

[1] T. H. Huxley, "Illustrations of the Structure of the Crossopterygian Ganoids" (Mem. Geol. Surv. dec. xii. 1866).

[2] O. M. Reis, "Die Cœlacanthinen, mit besonderer Berücksichtigung der im Weissen Jura Bayerns vorkommenden Gattungen" (Palæontographica, vol. xxxv. 1888).

The cranium of *Macropoma*, which may be regarded as a typical Cœlacanth, is well ossified and provided with robust membrane-bones. The roof of the skull is divisible "into two moieties, an anterior or frontal, and a posterior or occipito-parietal, which meet at an obtuse angle, the occipito-parietal moiety being nearly parallel with the base of the skull, while the frontal slopes obliquely forwards and downwards to the snout; the occipito-parietal portion is slightly convex from before backwards, and more so from side to side; while the frontal portion, though convex from side to side, is slightly concave from before backwards." The occipito-parietal region comprises a pair of large bones meeting in the middle line, evidently to be regarded as parietals, flanked postero-externally by a pair of triangular bones, which appear to represent the squamosal fused with the post-temporal. The frontals are long and narrow, separated by a suture at the median line, and flanked on each outer margin by a single series of small quadrate membrane-bones, which have been named parafrontals. The chondrocranium itself is extensively ossified, but there is no interorbital septum; and the base is formed by a long slender parasphenoid bone, which exhibits a spatulate expansion anteriorly.

The hyomandibular and pterygo-quadrate arcade are fused into a continuous triangular, lamelliform bone on each side, articulating with the hinder portion of the cranium above, and provided postero-inferiorly with a ginglymoid condyle for the articulation of the mandible below. The bone terminates in an attenuated angle in front, and its superior portion is inclined inwards, so that the inner surface forms the roof of the mouth; this surface is finely granulated and its lower border exhibits well-developed teeth, while the outer surface is smooth. In front of the pterygo-quadrates, a pair of thin small palatine bones, with more or less formidable teeth, occurs; and immediately in advance of these is a large azygous robust element, bearing a cluster of strong teeth, probably to be regarded as the coalesced vomers. The actual termination of the snout is not definitely known in *Macropoma*; but in the Upper Jurassic genera it is stated by von Zittel[1] to consist of a blunt rostrum, showing no sutures, and much resembling that of some of the early Dipnoi. The eye is surrounded by a ring of small, delicate sclerotic plates, suggestive of those of certain Palæozoic Amphibia. There are two large quadrate cheek-plates, one above the

[1] Handb. Palæont. vol. iii. p. 173. This description suggests that the undetermined snout from the Sussex Chalk noticed and figured by the present writer in Proc. Geol. Assoc. vol. xi. (1889), p. 31, pl. i, fig. 6, may pertain to *Macropoma*.

other, covering the space behind the eye, and immediately below these is another ornamented membrane-bone, triangular in shape, elongated antero-posteriorly, and named post-maxillary by Huxley. A single narrow, arched, suborbital element extends from the post-orbitals to the edge of the anterior portion of the cranial roof; and below this are indications of a long and narrow dentigerous maxilla, ornamented on its external aspect. The latter bone is termed palatine by von Zittel and Reis, but, as already perceived by Huxley, it has much more the appearance of an external element. The premaxilla is not certainly known. The greater portion of each mandibular ramus is formed by a long, narrow articulo-angular element, ornamented externally, having a nearly straight inferior margin, an arched superior margin in advance of the articulation, and exhibiting a short extension behind this facette. The small toothless dentary element meets this bone in front, reaching to the symphysis, and bounded below by a thin infradentary. A long, deep, laminar splenial bone, tapering in front, but with a straight dentigerous border in the greater part of its length, is apposed to the dentary and articulo-angular on their inner face; and this forms the inner wall of a vacuity existing between the upper portion of the two outer elements.

The robust ceratohyal on each side is connected with the hyo-mandibular by an elongated bone, with expanded extremities, which may be regarded as the stylo-hyal. This element is termed metapterygoid by Reis, and is supposed by that author to have supported a "præclavicular" fin. The latter determination, however, is founded upon two distorted fishes from the Bavarian Lithographic Stone, in the Munich Museum, which exhibit accidentally displaced fragments of the pectoral fin-rays at the postero-inferior angle of the head.

The branchial arches are four or five in number on each side, delicately and deeply channelled on the hinder aspect as in *Polypterus* and modern bony fishes. So far as has been definitely observed, each arch consists of a single pair of much arcuated elements, in some genera with sparse appended bony denticles; and a single large copula, with spatulate hinder extremity, unites all the lower extremities of the arches in the median line.

The notochord must have been persistent, and the present writer has not observed any satisfactory indications of ossified elements in the notochordal sheath. According to Reis[1], however, hypocentra are distinguishable in the so-called *Cœlacanthus hassiæ*. The

[1] *Op. cit.* p. 70, pl. iv. figs. 15, 16, 19.

neural arches and spines are long and slender, the two halves of each arch being firmly united with their appended spine. In the abdominal region, the hæmal arches are delicate and rudimentary, but in the caudal region they correspond in development to the opposed neural elements. So far as known, these ossifications extend only to the termination of the principal caudal fin, the small supplementary caudal never displaying hard endoskeletal structures.

The paired fins are always well-developed and obtusely lobate. The membrane-bones of the pectoral arch, though slender, are conspicuous, and seem to have been completely covered by the skin. The long, gently curved clavicle often exhibits a robust post-clavicular process, and articulates above with a small supraclavicle; while a long, slender infraclavicle overlaps its lower spatulate extremity. The last-mentioned element curves sharply forwards and inwards, terminating in a triangular expansion, where it meets its fellow of the opposite side in a median suture (see Pl. XIV. fig. 3, *i. cl.*). The pelvic fins are supported by a pair of elongated, slender basipterygia with an inwardly directed process at the distal end, by which they are loosely apposed in the median line.

Of the two dorsal fins, the anterior is destitute of baseosts, the stout dermal rays directly articulating with the nearly straight upper border of the single laminar axonost. This fin therefore exhibits no lobation. The posterior dorsal fin and the opposed anal resemble the paired fins in being distinctly lobate. As in the paired fins, the baseosts must have been too slightly ossified for preservation, the lobe being always a vacant space in the fossils; but there is a single forked axonost to each fin, this almost invariably exhibiting a high degree of ossification. The principal caudal fin is symmetrical, and supported by a single series of long slender bones above and below, equalling in number, and directly apposed to, the blunt distal extremities of the neural and hæmal spines of the axial skeleton. A single stout dermal ray is connected with each of these elements by a simple overlapping articulation; and a sparse series of very small rays fringing the supplementary caudal lobe, when present, is probably in direct contact with the unossified spines of the axial skeleton itself. None of the fin-rays are bifurcated, but all are more or less articulated distally.

A conspicuous feature in the abdominal region of all Cœlacanths is the ossified air-bladder, which attains a large size, and sometimes exhibits a single anterior aperture by which its internal cavity communicated with the œsophagus. Its walls are formed of three paired longitudinal series of large, imbricating, bony laminæ, each

composed of a number of superposed lamellæ; and the inner face is described by von Zittel as exhibiting large reticulating rugæ, suggestive of the network made known by Owen in the lung-like air-bladder of the recent *Protopterus*.

In all known genera, imbricating scales are present over the whole of the trunk, and the superficial layer of ganoine is not continuous, but arranged in tubercles and striæ. The lateral line is either inconspicuous or leaves no impression upon the scales.

Though ranging from the Lower Carboniferous to the Upper Chalk, the skeletal characters of the Cœlacanthidæ exhibit little variation; and it is difficult to recognize differences sufficiently marked to be regarded as justifying the subdivision of the family into a series of genera. The arrangement and proportions of the fins are almost constant, the supplementary caudal being apparently the only variable element. The other more important features available for generic diagnoses are (i) the ornamentation or otherwise of the head, opercular apparatus, and scales; (ii) the presence or absence of denticles upon the fin-rays; and (iii) the more or less jointed or non-jointed character of the rays themselves. One or two genera (*Libys* and *Heptanema*) are also apparently characterized by the relatively great development of the mucus-canals upon the head.

With regard to specific characters, imperfections in the preservation of the specimens render their precise determination often impossible. The number of rays in the median fins, especially the principal caudal, seems to vary in different species of the same genus; though this character can only be noted when there appears to have been no displacement of parts in the fossil. Minor variations in scale-ornament, and the ornamentation and proportions of the head and opercular bones, may also be cited as specific differences.

Synopsis of Genera.

I. No denticles or tuberculations on fin-rays.
Superficial ornament of more or less discontinuous ridges; supplementary caudal fin prominent ..... *Cœlacanthus* (p. 399).

II. Denticles or tuberculations on preaxial rays of anterior dorsal and caudal fins.
A. Fin-rays with numerous close articulations; supplementary caudal fin prominent.
No parafrontal pits; superficial ornament mostly tubercular; fin-rays very robust, articulated nearly to the base; supplementary caudal stout..... *Graphiurus* (p. 409)

Superficial ornament of irregular striæ; fin-rays articulated in distal half; supplementary caudal much elongated ..... *Diplurus* (p. 409).

No parafrontal pits; superficial ornament of irregular striæ and tubercles; fin-rays articulated for a long extent distally; supplementary caudal stout ..... *Undina* (p. 409).

Parafrontal and suborbital pits for enlarged mucus-follicles; otherwise resembling *Undina* ..... *Libys* (p. 413).

No parafrontal pits; superficial ornament of sparse tubercles, spinous on the scales; supplementary caudal stout..... *Coccoderma* (p. 415).

B. Fin-rays long and slender, articulated only for a short space distally; supplementary caudal fin apparently rudimentary or absent.

Parafrontals with pits for enlarged mucus-follicles; scale-ornament consisting of a prominent median spinous tubercle, with smaller tubercles above and below .... *Heptanema* (p. 415).

No parafrontal pits; superficial ornament of spinous tubercles ..... *Macropoma* (p. 416).

Of the genera thus enumerated, those named *Graphiurus*, *Diplurus*, and *Coccoderma* seem least entitled to distinction, being separated from *Undina* (so far as known) only by characters of slight importance.

Genus **CŒLACANTHUS**, Agassiz.

[Poiss. Foss., Feuill. 1836, p. 83, and vol. ii. pt. ii. 1844, p. 170.]

Syn. *Hoplopygus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. 1844, p. 178.
Conchiopsis, E. D. Cope, Proc. Acad. Nat. Sci. Philad. 1873, p. 341.
Rhabdoderma, O. M. Reis, Palæontographica, vol. xxxv. 1888, p. 71.

The typical genus. Teeth absent on the margin of the jaws, but a few hollow, conical teeth within. Supplementary caudal fin prominent; the rays of all the fins long and slender, unjointed for a considerable length proximally, closely articulated, but without expansion, distally; denticles absent upon all the rays. External bones and scales superficially ornamented with series of tubercles or fine ridges of ganoine.

Cœlacanthus granulatus, Agassiz.

1829. "Fossil Fish," A. Sedgwick, Trans. Geol. Soc. [2] vol. iii. p. 118, pl. xi.

1839. *Cœlacanthus granulatus*, L. Agassiz, *op. cit.* vol. ii. pl. lxii. (name and fig. only).

1842. *Cœlacanthus hassiæ*, G. von Münster, Beitr. Petrefakt. v. p. 49. [Head and abdominal region; British Museum, and Palæontological Museum, Munich].

1844. *Cœlacanthus granulosus*, L. Agassiz, *op. cit.* vol. ii. pt. ii. p. 172.

1850. *Cœlacanthus granulatus*, Sir P. Egerton, in King's Permian Foss. (Pal. Soc.), p. 235, pl. xxviii*.

1850. *Cœlacanthus caudalis*, Sir P. Egerton, *ibid.* p. 236, pl. xxviii. fig. 2. [Immature fish; British Museum.]

1861. *Pygopterus humboldti*, H. B. Geinitz (*errore*), Dyas, pl. viii. figs. 1–3.

1866. *Cœlacanthus caudalis*, T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. xii. pp. 14, 21, pl. v. fig. 5.

1869. *Cœlacanthus macrocephalus*, R. von Willemoes-Suhm, Palæontographica, vol. xvii. p. 74, pl. xi. fig. 2. [Head and abdominal region; Palæontological Museum, Munich.]

1869. *Cœlacanthus hassiæ*, R. von Willemoes-Suhm, *ibid.* p. 76, pl. x. fig. 1, pl. xi. fig. 1.

1888. *Cœlacanthus macrocephalus*, O. M. Reis, Palæontographica, vol. xxxv. p. 68.

1888. *Cœlacanthus hassiæ*, O. M. Reis, *ibid.* p. 69, pl. iii. fig. 22, pl. iv. figs. 7, 12, 15, 16, 19.

1890. *Cœlacanthus granulosus*, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata, pp. 39, 40.

Type. Caudal region; British Museum.

The type species, attaining a length of about 0·45. Trunk robust, but elongated. Dorsal fins of relatively large size, the first consisting of about 10–12 rays and situated slightly in advance of the pelvic pair, the second consisting of more numerous slender rays; principal caudal fin comprising about 20 stout rays above and below. Scales ornamented with coarse, antero-posteriorly elongated tubercles, often arranged in series.

Form. & Loc. Upper Permian (Marl Slate); Durham. Upper Permian (Kupferschiefer): Germany.

P. 3338. Type specimen figured by Agassiz, *tom. cit.* pl. lxii. fig. 1; Marl Slate, Ferry Hill. *Enniskillen Coll.*

P. 3339–40. Three imperfect specimens showing portions of the head and anterior abdominal region; two from Fulwell Hill, the third from Midderidge. The bones are much

crushed and broken, and there are remains of widely spaced, hollow, conical teeth on an elongated slender element in each of the two specimens entered under the first number. *Enniskillen Coll.*

P. 554. Caudal region figured in King's Permian Foss. pl. xxviii.*; Ferry Hill. *Egerton Coll.*

P. 3339 a. Imperfect caudal region of small individual; Fulwell Hill. *Enniskillen Coll.*

P. 555, P. 3335. Immature individual, in counterpart, labelled *C. granulatus* by Agassiz, but described by Egerton as the type of a distinct species, *C. caudalis*; Ferry Hill. *Egerton & Enniskillen Colls.*

38586. Counterpart of type specimen of *C. hassiæ*, Münster; Riechelsdorf, Hesse. The fossil in the Münster Collection, Munich, is described and figured by Willemoes-Suhm in the Palæontographica, vol. xvii. p. 77, pl. x. fig. 1. Though not recognized by Münster, some of the characteristic granulated scales are distinctly exhibited. *Purchased*, 1864.

40372, 43429. Imperfect head and abdominal region, in counterpart, showing the characteristic squamation and portions of the paired and first dorsal fins; the first-mentioned side of the fossil also exhibiting a few hollow, conical teeth; Riechelsdorf. *Purchased*, 1865, *and Presented by Kenneth Murchison, Esq.*, 1872.

43427, P. 3342. Remains of head and abdominal region of a large individual, in counterpart; Riechelsdorf. The clavicles are well displayed. *Presented by Kenneth Murchison, Esq.*, 1872, *& Enniskillen Coll.*

43426. Portion of abdominal and caudal regions, displaying the dorsal and anal fins, and portions of the principal caudal and pelvic pair; Riechelsdorf. *Presented by Kenneth Murchison, Esq.*, 1872.

P. 753. Imperfect remains of abdominal and caudal regions; Riechelsdorf. *Egerton Coll.*

P. 3342 a, b. Fragments of caudal region, the second in counterpart; Riechelsdorf. *Egerton & Enniskillen Colls.*

Cœlacanthus tingleyensis, Davis.

1884. *Cœlacanthus tingleyensis*, J. W. Davis, Trans. Linn. Soc. ser. 2, (Zoology), vol. ii. p. 427, pls. xlvi.–xlix.
1888. *Rhabdoderma tingleyense*, O. M. Reis, Palæontogr. vol. xxxv. p. 72.

Type. Various portions of fishes; collection of J. W. Davis, Esq.

A large species, about equal to the typical *C. granulatus* in size. Trunk robust, but elongated. Dorsal fins of relatively large size, the first consisting of very stout rays and situated slightly in advance of the pelvic pair, the second consisting of more numerous slender rays; principal caudal fin comprising 18–20 stout rays above and below. Jugular plates ornamented with fine, concentric, and vermiculating ridges; operculum and some of the cranial roof-bones with the ornament partly consisting of series of tuberculations; scales ornamented with fine antero-posterior ridges, sometimes irregularly constricted at intervals, sometimes divided into series of elongated tubercles.

Form. & Loc. Middle Coal-Measures: Yorkshire.

The following specimens were presented by the Earl of Enniskillen, 1882:—

P. 1187. Remains of a small head, opercular apparatus, clavicle, and a few scales, labelled by J. W. Davis; Tingley.

P. 1187 a–c. Three specimens, similarly labelled, the first and second displaying remains of the head and abdominal region, the third exhibiting the principal caudal fin; Tingley.

P. 1188. Well-preserved large scales, probably of this species; Tingley.

The original of the following specimen is not yet clearly distinguished from *C. tingleyensis*:—

42062. Plaster cast of caudal region of a large fish, named *C. phillipsi*, L. Agassiz (Poiss. Foss. vol. ii. pt. ii. 1844, p. 173), and subsequently described by J. W. Davis, Geol. Mag. [3] vol. vii. (1890), p. 159; Lower Coal-Measures, Halifax, Yorkshire. The original specimen is preserved in the Halifax Museum.

Presented by Rev. J. B. Reade, 1870.

Cœlacanthus elegans, Newberry.

[Plate XIV. fig. 2.]

1844. *Cœlacanthus lepturus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 173 (undefined).

1844. *Hoplopygus binneyi*, L. Agassiz, *ibid.* p. 178 (undefined). [E. W. Binney Collection.]

1856. *Cœlacanthus elegans*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. p. 98.

1866. *Cœlacanthus lepturus*, T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. xii. p. 16, pl. ii. figs. 1–4, pl. iii. figs. 1–3, pl. iv. figs. 1–6. [Museum of Practical Geology.]

1866. *Cœlacanthus elegans*, T. H. Huxley, *ibid.* p. 20, pl. v. figs. 1–4.

1872. *Cœlacanthus lepturus*, A. Hancock & T. Atthey, Ann. Mag. Nat. Hist. [4] vol. ix. p. 256, pl. xvii. fig. 4; also Nat. Hist. Trans. Northumb. & Durham, vol. iv. p. 416, pl. xv. fig. 4.

1873. *Conchiopsis filiferus* and *C. anguliferus*, E. D. Cope, Proc. Acad. Nat. Sci. Philad. p. 342. [Imperfect fishes; Columbia College, New York.]

1873. *Cœlacanthus elegans*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. p. 425, and Rep. Geol. Surv. Ohio, vol. i. pt. ii. p. 339, pl. xl. fig. 1.

1875. *Cœlacanthus lepturus*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 242.

1876. *Cœlacanthus lepturus*, J. W. Davis, Quart. Journ. Geol. Soc. vol. xxxii. p. 339.

1888. *Rhabdoderma lepturus* and *R. elegans*, O. M. Reis, Palæontogr. vol. xxxv. p. 5.

1889. *Cœlacanthus elegans*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi.), p. 213.

1890. *Cœlacanthus lepturus*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 168, pl. v. figs. 1, 3.

1890. *Cœlacanthus lepturus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 390.

Type. Imperfect fishes; Columbia College, New York.

A species usually attaining only a small size, but sometimes probably having a total length of not less than 0·45. Body slender and elongated; head with opercular apparatus occupying about one-fifth of the total length. Dorsal fins of relatively large size, the first consisting of very stout rays and situated slightly in advance of the pelvic pair, the second consisting of more numerous slender rays; principal caudal fin comprising 12–14 stout rays above and below. Jugular plates tapering in front, three to three and a half times as long as broad, ornamented with fine vermiculating striæ, in part concentric; operculum about one and a half times as deep as broad, irregularly marked with short, fine, vermiculating striæ,

more or less concentric with the three margins. Cranial roof-bones in part ornamented with series of tuberculations. Scales pointed, very finely striated, the striæ directed antero-posteriorly and converging behind, more or less irregular, often divided into elongated tubercles in the hinder portion.

This is the type species of *Hoplopygus*, *Conchiopsis*, and *Rhabdoderma*.

Form. & Loc. Coal-Measures: Ohio, England, and Scotland. Culm-Measures: North Devonshire.

P. 579–81. Three specimens described and figured by Huxley, *op. cit.* p. 20, pl. v. figs. 1–4; Linton, Ohio. *Egerton Coll.*

P. 746. Typical specimen, wanting the pectoral fins, the second dorsal, and the terminal caudal; Linton. *Egerton Coll.*

P. 3334. Imperfectly preserved fish, wanting the pectoral and terminal caudal fins; Linton. *Enniskillen Coll.*

P. 3332. Imperfect caudal region, showing the terminal fin, labelled *Cœlacanthus lepturus* by Agassiz; Leeds. *Enniskillen Coll.*

36477. Remains of fish displaying the dorsal fins and the principal caudal; Longton, N. Staffordshire. *Purchased*, 1862.

P. 748. Remains of trunk showing portions of the air-bladder; Deep Mine, Longton. *Egerton Coll.*

P. 3330–31. Two imperfect fishes; Knowles Ironstone Shale, Fenton, and Deep Mine, Longton. *Enniskillen Coll.*

P. 5177. Small fish, with well-preserved scales; Longton. *Purchased*, 1885.

42382. Imperfect fish; Gubbin Ironstone, Tipton, S. Staffordshire. *Purchased*, 1870.

40393. Smaller specimen, in counterpart, wanting head; Tipton. *Purchased*, 1866.

30572. Fish with portions of well-preserved fins; Dalemoor-Rake Ironstone, Stanton-by-Dale, Derbyshire. *Purchased*, 1856.

48055. More imperfectly preserved specimen, in counterpart, displaying the principal caudal fin; Dalemoor-Rake Ironstone, Stanton-by-Dale. *Presented by Moses Rigley, Esq.*, 1877.

37956. Crushed specimen showing part of the terminal caudal fin; Airdrie, Lanarkshire. *Purchased*, 1863.

21464. Small individual in counterpart; Carluke. *Purchased*, 1847.

41197. Fragmentary remains of small individual; Low Main Seam, Newsham, Newcastle-upon-Tyne. *Purchased*, 1868.

21952. Detached head, much crushed, inferior aspect; Carluke. *Purchased*, 1847.

P. 751. Pterygo-suspensorium; Lowmoor, Yorkshire. *Egerton Coll.*

P. 3333. Pterygo-suspensorium; Lowmoor. *Enniskillen Coll.*

The following specimens are regarded as pertaining to an undescribed species by T. M. Hall, Geol. Mag. [2] vol. iii. (1877), p. 410. The only differences from the typical *C. elegans*, however, seem to be due to the circumstances of fossilization:—

P. 5379, P. 6286. Fine specimen, in counterpart, discovered by W. Porter, Esq., in a bed of nodules, of the Culm-Measures, near Instow. One side of the split nodule is shown, of the natural size, in Pl. XIV. fig. 2, some bones of the head and opercular apparatus being introduced from the opposite side. The pectoral fins are almost entirely wanting, and the ventral portion of the abdominal region is partly displaced by crushing. The head is also imperfectly preserved; and an irregular ferruginous mass appears to indicate the position and extent of the air-bladder. One of the jugular plates (*ju.*) is displaced beneath the articulo-angular bone (*d.*) and exhibits a remarkably acuminate anterior extremity. There is evidence of two or three ornamented cheek-plates (*x.*) behind the eye; and the impression of a narrow bone forms the lower boundary of the orbit. The triangular operculum (*op.*), with its fine ornamentation, seems to be completely preserved as an impression; and there are traces behind this of the pectoral arch. The characters of the fins and squamation, so far as recognizable, are noted in the specific diagnosis. The scales seem to occur merely as impressions, and those of the flank (fig. 2 *a*) thus appear to be marked with extremely delicate convergent lines (the infilling of the fissures between the original ridged ornament), which meet in a posterior reticulation.
Purchased, 1886, *and presented by W. Porter, Esq.*, 1890.

P. 6101. Group of scales and fragments of head-bones; Instow. *Purchased*, 1886.

Cœlacanthus robustus, Newberry.

1856. *Cœlacanthus robustus*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. p. 98.
1873. *Cœlacanthus robustus*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. p. 341, pl. xl. fig. 2.
1888. *Rhabdoderma robustum*, O. M. Reis, Palæontogr. vol. xxxv. p. 5.

Type. Imperfect fishes; Columbia College, New York.

A species of moderate size, not very satisfactorily distinguished from *C. elegans*. Jugular plates rapidly tapering and acuminate in front, three and a half times as long as broad; operculum somewhat less than one and a half times as deep as broad; both ornamented with fine, concentric, and vermiculating striæ. Cranial roof-bones tuberculated. Scales as in *C. elegans*.

Form. & Loc. Coal-Measures: Ohio.

P. 747. Two examples of the operculum and remains of a head showing portions of the jugular plates, labelled by Dr. Newberry; Linton, Ohio. *Egerton Coll.*

Cœlacanthus elongatus, Huxley.

1866. *Cœlacanthus elongatus*, T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. xii. p. 23, pl. v. figs. 6, 7.

Type. Imperfect fishes: Geological Survey of Ireland.

An imperfectly known species, with well-developed fins; apparently distinguished from other species hitherto described in the narrow elongated form of the head and trunk.

Form. & Loc. Coal-Measures; Ballyhedy near Ballinhassig, Co. Cork.

Not represented in the Collection.

According to J. S. Newberry (Rep. Geol. Surv. Ohio, vol. i. pt. ii. 1873, p. 340), *C. elongatus* is probably represented in America by a species from the Coal-Measures of Linton, Ohio, named *C. ornatus*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. (1856), p. 98, and Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 227. By O. M. Reis (Palæontogr. vol. xxxv. 1888, p. 5) the former is retained in the genus *Cœlacanthus*, while the latter is removed to the so-called *Rhabdoderma*.

Cœlacanthus huxleyi, Traquair.

[Plate XIV. fig. 1.]

1881. *Cœlacanthus huxleyi*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 20, pl. i. figs. 1–4.

1888. *Rhabdoderma huxleyi*, O. M. Reis, Palæontogr. vol. xxxv. p. 5.

Type. Imperfect fishes; Geological Survey of Scotland.

A small species, attaining a maximum length of about 0·18. Trunk robust but elongated; head with opercular apparatus occupying about one fourth of the total length. Dorsal fins of relatively large size, the first consisting of very stout rays and situated slightly in advance of the pelvic pair, the second consisting of more numerous slender rays; principal caudal fin comprising about 14 stout rays above and below. Jugular plates four times as long as broad, ornamented with few, delicate, concentric striæ; opercular bones three-quarters as broad as deep, smooth or feebly striated; head-bones in part marked with few coarse striæ, sometimes divided into elongated tubercles; scales externally ornamented with very delicate, widely spaced, posteriorly converging striæ.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4079 a. Large individual, in counterpart, wanting terminal caudal fin, probably originally about 0·18 in total length. A jugular plate, the opercular bones, and calvicle, as preserved, exhibit none but the faintest external ornamentation; but one of the cheek-plates is externally marked with a few coarse concentric striæ and irregular tubercles. *Purchased*, 1883.

P. 4079 b. Specimen about 0·105 in length, with imperfect head and fins. *Purchased*, 1883.

P. 4080 a. Small individual showing the terminal caudal fin, represented, of the natural size, in Pl. XIV. fig. 1, the scales and jugular plate being enlarged three times in figs. 1 *a*, 1 *b*. *Purchased*, 1883.

P. 4080 b. Similar specimen, displaying the dorsal fins. *Purchased*, 1883.

P. 4079–80. Six small fishes, some showing smooth opercular bones. *Purchased*, 1883.

P. 5983. Small individual. *Purchased*, 1889.

Cœlacanthus gracilis, Agassiz.

1844. *Cœlacanthus gracilis*, L. Agassiz, Pois. Foss. vol. ii. pt. ii. p. 173.

Type. Portion of caudal region; British Museum.

An imperfectly definable species, known only by the type specimen mentioned below. Body apparently elongated and slender; principal caudal fin comprising about 14 widely-spaced rays above and below; scales in part coarsely striated, in part tuberculated.

Form. & Loc. Unknown (? Muschelkalk, Germany).

P. 3341. Type specimen, 0·11 in length, comprising the principal caudal fin and a portion of the caudal region in advance of this. The body is very narrow, and the caudal fin-rays are relatively long, showing wide articulations distally. Several portions of scales occur, and there are apparently traces of fossilized muscle. *Enniskillen Coll.*

The following specimens are also probably referable to a species of *Cœlacanthus*:—

P. 3346–51. Jugular plate and five other external bones, ornamented with irregular striæ, ascribed to *Cœlacanthus* by J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 524, pl. lxiii. figs. 7–12; Lower Carboniferous Limestone, Armagh. *Enniskillen Coll.*

The undefined species, *Cœlacanthus minor*, Agassiz (Poiss. Foss. vol. ii. pt. ii. 1844, p. 173), from the Muschelkalk of Lunéville, may pertain either to this genus or to *Heptanema*.

The genus *Peplorhina*, E. D. Cope (Proc. Acad. Nat. Sci. Philad. 1873, pp. 343, 418), is placed near to *Cœlacanthus* (*Conchiopsis*) by its founder, but regarded as Amphibian by J. S. Newberry (*ibid.* p. 426). The type species, from the Coal-Measures of Linton, Ohio, is named *P. anthracina*, E. D. Cope (*ibid.* p. 343, and Rep. Geol. Surv. Ohio, vol. ii. pt. ii. 1875, p. 410, pl. xxxv. fig. 6, pl. xli. figs. 4, 5), and also includes *Conchiopsis exanthematicus*, E. D. Cope (Proc. Acad. Nat. Sci. Philad. 1873, p. 342). The type specimens are in the Museum of Columbia College, New York. A diamond-shaped dentigerous plate, from the Permian of East Illinois, has also been assigned to the genus under the name of *P. arctata*, E. D. Cope (Proc. Amer. Phil. Soc. vol. xvii. 1878, p. 54).

Genus **GRAPHIURUS,** Kner.

[Sitzungsb. k. k. Akad. Wiss. Wien, math.-naturw. Cl. vol. liii. pt. i. 1866, p. 155.]

Supplementary caudal fin prominent; the rays of all the fins broad, expanded, distally pointed, and closely articulated almost to the base; preaxial rays of the first dorsal and caudal fins tuberculated. Scales and head-bones tuberculated.

So far as known, this genus comprises only one small species, of which there are no specimens in the Collection :—

Graphiurus callopterus, R. Kner, Sitzungsb. k. k. Akad. Wiss. Wien, math.-naturw. Cl. vol. liii. pt. i. (1866), p. 155, pl. i.; O. M. Reis, Palæontographica, vol. xxxv. (1888), p. 67, pl. v. figs. 9, 10.—Upper Keuper; Raibl, Carinthia. [Imperial Geological Survey, Vienna.]

Genus **DIPLURUS,** Newberry.

[Ann. New York Acad. Sci. vol. i. 1878, p. 127.]

Supplementary caudal fin prominent, with much elongated pedicle; fin-rays robust, closely articulated in the distal half; preaxial rays of the first dorsal and caudal fins with spinous tubercles. Scales and head-bones irregularly striated.

So far as known, this genus comprises only one large species, of which there are no specimens in the Collection :—

Diplurus longicaudatus, J. S. Newberry, *loc. cit.* p. 127, and Foss. Fishes Trias, N. Jersey and Connecticut (Mon. U. S. Geol. Surv. no. xiv. 1888), p. 74, pl. xx.—Trias; New Jersey and Connecticut, U. S. A. [Columbia College, New York.]

Genus **UNDINA,** Münster.

[Neues Jahrb. 1834, p. 539.]

Syn. *Holophagus*, Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains, dec. x. (Mem. Geol. Surv. 1861), p. 19.

Teeth absent on the margin of the jaws, but a few hollow, conical teeth within. Supplementary caudal fin prominent; the rays of all the fins broad and robust, often expanded, and closely articulated in the distal portion; small, upwardly-pointing denticles on the preaxial rays of the first dorsal and caudal fins. External bones and scales superficially ornamented with tubercles or fine interrupted ridges of ganoine; parafrontal and circumorbital bones plate-like, without superficial excavations.

Undina penicillata, Münster.

1834. *Undina penicillata*, G. von Münster, Neues Jahrb. p. 539.
1842. *Cœlacanthus striolaris*, G. von Münster, Neues Jahrb. p. 40. [Palæontological Museum, Munich.]
1842. *Cœlacanthus kohleri*, G. von Münster, *ibid.* p. 40. [Ibid.]
1842. *Cœlacanthus striolaris*, G. von Münster, Beitr. Petrefakt. pt. v. p. 57, pl. ii. figs. 1, 3, 5, 6, 8–10, 12, 14, 16.
1842. *Cœlacanthus kohleri*, G. von Münster, *ibid.* p. 59, pl. ii. figs. 2, 4, 7, 11, 13, 15, 17.
1844. *Undina striolatus* and *U. kohleri*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 171.
1863. *Undina penicillata*, A. Wagner, Abh. math.-phys. Cl. k.-bay. Akad. Wiss. vol. ix. p. 696.
1869. *Cœlacanthus penicillatus*, R. von Willemoes-Suhm, Palæontographica, vol. xvii. p. 80, pl. x. figs. 2, 3, pl. xi. fig. 3.
1871. *Cœlacanthus harlemensis*, T. C. Winkler, Archives Mus. Teyler, vol. iii. p. 101, pl. iv. [Teyler Museum, Haarlem.]
1881. *Cœlacanthus harlemensis*, B. Vetter, Mittheil. k. mineral.-geol. Mus. Dresden, pt. iv. p. 13, pl. ii. fig. 4.
1887. *Undina penicillata*, K. A. von Zittel, Handb. Palæont. vol. iii. p. 175, woodc. fig. 177.
1887. *Undina acutidens*, K. A. von Zittel, *ibid.* p. 175, woodc. fig. 177 *b* (fig. of scales only).
1888. *Undina penicillata*, O. M. Reis, Palæontographica, vol. xxxv. pp. 30, 36, pl. ii. figs. 5, 6, 9, 10, pl. iv. figs. 3, 4.
1888. *Undina acutidens*, O. M. Reis, *ibid.* pp. 10, 36, pl. i. figs. 2–6, 8–24. [Palæontological Museum, Munich.]

Type. Nearly complete individual; Palæontological Museum, Munich.

The type species, attaining a length of about 0·4. Trunk robust, but elongated; head and opercular apparatus occupying somewhat less than one quarter of the total length. Fin-rays slightly expanded in the articulated distal half; dorsal fins well developed, the first consisting of about 10 relatively stout rays, the second and the anal each comprising at least twice that number of more slender rays; principal caudal fin comprising about 18–20 stout rays above and below. Jugular plates four times as long as broad, covered with sparse elongated tubercles; operculum, cheek-plates, and mandible delicately tuberculated. Scales ornamented with numerous irregularly and closely arranged, elongated tubercles.

The occasional smooth appearance of the jugular, operculum, and cheek-plates of this species is doubtless owing to post-mortem accident before or during fossilization. The same remark probably applies to the varying presence or absence of the larger teeth among the smaller ones.

Form. & Loc. Lower Kimmeridgian (Lithographic Stone): Bavaria.

49143. Plaster cast of type specimen, figured by von Zittel, *tom. cit.* p. 175, woodc. f. 177; Zandt, near Eichstädt.

Purchased, 1878.

37032. Imperfectly preserved fish, in counterpart, wanting the terminal caudal fin; Solenhofen. An external ornament of large elongated tubercles, closely arranged, is seen upon a bone probably pertaining to the mandible.

Häberlein Coll.

P. 5543. Well-preserved specimen, 0·4 in length, wanting portions of the head and the terminal caudal fin; Eichstädt. A few large conical teeth and some of the sclerotic plates are exhibited; and below the mandible is the impression of a large jugular plate of which a fragment shows the ornament. The scales of the flanks are ornamented by short striæ, fewer and more elongated than those upon the scales figured by von Zittel as *U. acutidens*.

Purchased, 1888.

It still remains doubtful whether the following supposed distinct species is not founded upon a young individual of *U. penicillata*:—

Undina minuta, A. Wagner, Abh. math.-phys. Cl. k.-bay. Akad Wiss. vol. ix. (1863) p. 697; O. M. Reis, Palæontogr. vol. xxxv. (1888), pp. 6, 30, 36, pl. i. fig. 1: *Cœlacanthus minutus*, R. von Willemoes-Suhm, Palæontogr. vol. xvii. (1869), p. 79, pl. xi. fig. 4: *Undina cirinensis*, V. Thiollière, Poiss. Foss. Bugey, pt. i. (1854), p. 10.—Lower Kimmeridgian (Lithographic Stone); Cirin, Ain, France, and Bavaria. [Palæontological Museum, Munich.]

Undina gulo (Egerton).

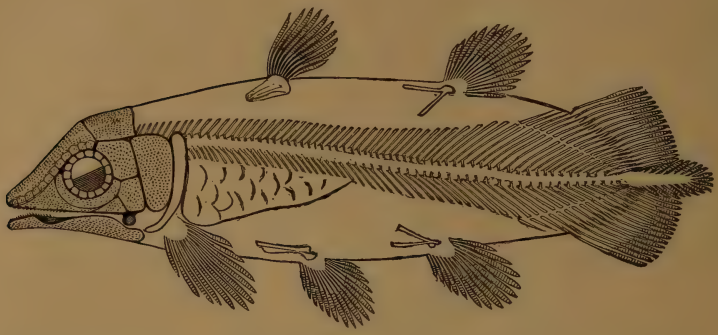
1861. *Holophagus gulo*, Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. x. p. 19.
1866. *Holophagus gulo*, T. H. Huxley, *ibid.* dec. xii. p. 26, pl. vi.
1872. *Holophagus gulo*, T. H. Huxley, *ibid.* dec. xiii. no. 10, pl. x.

Type. Fish, wanting head; Museum of Practical Geology.

A large species, attaining a length of about 0·7. Trunk robust; head and opercular apparatus occupying one quarter of the total length. Dorsal fins well developed, the first consisting of about 10 relatively stout rays, the second and the anal comprising more

numerous and more slender rays, much expanded and closely articulated distally; principal caudal fin consisting of about 16–18 stout rays above and below, much expanded and closely articulated distally. Mandibular and opercular bones and jugular plates externally ornamented with large, very closely arranged, rounded tubercles; scales with numerous, irregularly and closely arranged, elongated tubercles.

Fig. 53.



Undina gulo (Egert.).—Restored skeleton. The supraclavicle is omitted, and the cheek-plates are inferred to have been arranged as in other Cœlacanths. The facial bones in advance of the orbit are unknown.

This is the type species of the so-called *Holophagus*.

Form. & Loc. Lower Lias: Lyme Regis, Dorsetshire.

P. 3344. Specimen figured in Mem. Geol. Surv. dec. xiii. pl. x. *Enniskillen Coll.*

P. 2022. Fine small specimen, 0·255 in length, wanting the pelvic and anal fins, and parts of the anterior dorsal and supplementary caudal. The ornament of one of the jugular plates is well preserved. *Egerton Coll.*

P. 2022 a. Fragmentary remains of head and caudal region. The rays of the caudal fin considerably overlap the extremities of the supporting bones. *Egerton Coll.*

P. 875. Fragments of head and anterior dorsal fin. *Egerton Coll.*

Undina (?) barroviensis, A. S. Woodward.

1890. *Undina barroviensis*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. p. 436, pl. xvi. fig. 5.

Type. Fish, wanting paired fins; British Museum.

An imperfectly definable species, known only by the specimen mentioned below. Fin-rays not expanded distally, with more widely-spaced articulations than in the typical species; principal caudal fin consisting of about 16–18 rays above and below. Scales ornamented with few, large, irregular, elongated tubercles, sometimes subdivided transversely.

Form. & Loc. Lower Lias: Barrow-on-Soar, Leicestershire.

21335, P. 3343. Type specimen, in counterpart, described and figured, *loc. cit.* *Purchased*, 1847, *and Enniskillen Coll.*

The specimens mentioned below probably indicate an undetermined species of *Undina*, as remarked by the present writer in Proc. Geol. Assoc. vol. xi. (1890), p. 292:—

P. 4277. Pterygo-suspensorial bone figured, *loc. cit.* pl. iii. fig. 6; Stonesfield Slate, near Oxford. *Enniskillen Coll.*

P. 3793. A more imperfect example of the same bone; Stonesfield Slate. *Enniskillen Coll.*

P. 4277 a. Jugular plate, resembling a specimen figured by C. Prevost, Ann. Sci. Nat. vol. iv. (1825), pl. xviii. fig. 20. *Enniskillen Coll.*

Genus **LIBYS,** Münster.

[Neues Jahrb. 1842, p. 45.]

Fin-rays broad and robust, often expanded, and closely articulated in the distal half; the preaxial rays of the first dorsal and caudal fins granulated. Parafrontal and circumorbital bones with a regular series of very large, broad vacuities or superficial excavations; scales ornamented with irregularly disposed, elongated tubercles.

This genus is closely related to *Undina*, and was first elucidated by O. M. Reis (Palæontographica, vol. xxxv. 1888, p. 37.). The vacuities or excavations in the parafrontal and circumorbital bones probably imply a large development of the mucus-secreting follicles of the sensory canals.

Libys polypterus, Münster.

1842. *Libys polypterus*, G. von Münster, Neues Jahrb. p. 45.
1866. *Cœlacanthus* (*Undina*) *kohleri*, T. H. Huxley (*errore*), Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. xii. p. 42.
1888. *Libys polypterus*, O. M. Reis, Palæontographica, vol. xxxv. pp. 37, 50, pl. iii. figs. 1–11.

Type. Fragment of head; Palæontological Museum, Munich.

The type species, imperfectly known. Jugular plates long and narrow, the maximum breadth being contained about five and a half times in the total length. Scales [so far as known] ornamented with large, closely arranged, elongated tubercles.

This provisional diagnosis is given on the assumption that the specimen mentioned below is correctly determined.

Form. & Loc. Lower Kimmeridgian (Lithographic Stone): Bavaria.

P. 3337. Specimen described by Huxley, *loc. cit.*, under the name of *Cœlacanthus* (*Undina*) *kohleri*; Kelheim. The head exhibits the excavated parafrontals, regarded as characteristic of the genus *Libys*; but a few scales in advance of the first dorsal fin are indistinguishable from those of the typical *Undina penicillata*, and Huxley may be correct in describing the ornamentation of the cranial bones as having "disappeared" accidentally. The narrow jugular plates are well displayed from the inner aspect, each measuring about 0·06 in length and 0·11 in maximum breadth. *Enniskillen Coll.*

Libys superbus, Zittel.

1887. *Libys superbus*, K. A. von Zittel, Handb. Palæont. vol. iii. p. 175, woodc. fig. 179.
1888. *Libys superbus*, O. M. Reis, Palæontographica, vol. xxxv. pp. 41, 50, pl. ii. figs. 1–4.

Type. Nearly complete individual; Palæontological Museum, Munich.

Body short and robust; head with opercular apparatus occupying less than one quarter of the total length. Jugular plates broad, the maximum breadth being contained about three and a half times in the total length; ornamented with few fine striæ. Scales with a sparse ornament of elongated tubercles.

Form. & Loc. Lower Kimmeridgian (Lithographic Stone): Bavaria.

Not represented in the Collection.

Genus **COCCODERMA,** Quenstedt (*emend.* Reis).

[Der Jura, 1858, p. 810 (*Kokkoderma*).]

Supplementary caudal fin stout and prominent, the rays of all the fins broad and robust, often expanded, and closely articulated in the distal portion; small granulations on the preaxial rays of the first dorsal and caudal fins. External ornament consisting of sparse tubercles, which become numerous and spinous on the scales; parafrontal and circumorbital bones plate-like, without superficial excavations.

This genus was founded upon a detached pterygo-suspensorial bone, described as a problematical fossil by Quenstedt. The definition here given is based upon the researches of O. M. Reis (Palæontogr. vol. xxxv. 1888, p. 60), who recognizes three species, of which there are no specimens in the Collection :—

Coccoderma gigas, O. M. Reis, *loc. cit.* (1888), p. 57, pl. iii. fig. 17–19.—Lithographic Stone (Lower Kimmeridgian); Bavaria. [Jaws; Munich Museum.]

Coccoderma substriolatum, O. M. Reis, *ibid.* p. 51: *Macropoma substriolatum*, T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv. 1866), dec. xii. p. 39, pls. ix., x.—Kimmeridge Clay; Cottenham. [Skull and portion of trunk; Woodwardian Museum, Cambridge.]

Coccoderma suevicum, F. A. Quenstedt, Der Jura (1858), p. 810, pl. 100. fig. 14; O. M. Reis, *loc. cit.* p. 51, pl. v. figs. 1, 2, 4, 8, 11, pl. iv. fig. 16: *Undina major*, A. Wagner, Abh. math.-phys. Cl. k.-bay. Akad. Wiss. vol. ix. (1863), p. 697: *Cœlacanthus major*, R. von Willemoes-Suhm, Palæontogr. vol. xvii. (1869), p. 82.—Lithographic Stone (Lower Kimmeridgian); Würtemberg and Bavaria. [Pterygo-suspensorial bone; Tübingen Museum. Type species.]

Undefined fragments from the Bavarian Lithographic Stone are also named *Coccoderma nudum*, Reis (*loc. cit.* p. 60, pl. iii. fig. 16, pl. v. fig. 1), and *C. bavaricum*, Reis (*ibid.* p. 60, pl. v. fig. 2). The types are in the Munich Museum.

Genus **HEPTANEMA,** Bellotti.

[C. Bellotti, in A. Stoppani, Studii Geol. e Paleont. Lombardia, 1857, p. 435.]

Fin-rays robust and straight, not expanded, and only articulated for a relatively short extent distally; the preaxial rays of the first dorsal and caudal fins with a double series of upwardly-pointed

denticles; [supplementary caudal fin "rudimentary or absent"]. Operculum and jugular plates ornamented with hollow spinous tubercles; the scales with a large median spinous tubercle flanked by one or two pairs of similar but smaller tubercles.

There are no examples of this genus in the Collection, but the following species are recognized:—

Heptanema paradoxum, C. Bellotti, in A. Stoppani, *op. cit.* 1857, p. 435; W. Deecke, Palæontogr. vol. xxxv. (1889), p. 112, pl. vii. fig. 3.—Upper Keuper; Perledo, Lake of Como. [Imperfect fish; Milan Museum. The type species.]

Heptanema willemoesi, O. M. Reis, Palæontogr. vol. xxxv. (1888), p. 64, pl. iii. figs. 20, 21: *Macropoma willemoesii*, B. Vetter, Mittheil. k. mineral.-geol. Mus. Dresden, pt. iv. (1881), p. 1, pl. i. fig. 1.—Lower Kimmeridgian (Lithographic Stone); Bavaria. [Royal Mineralogical Museum, Dresden.]

An undetermined Cœlacanth, possibly of this genus, from the Keuper of Coburg, is also noticed and figured by H. A. C. Berger, Verstein. Sandst. Coburg. Gegend (1832), p. 18, pl. i. fig. 2.

Genus **MACROPOMA**, Agassiz.

[Poiss. Foss., Feuilleton, 1835, p. 55.]

Maxilla provided with irregularly-arranged large and small conical teeth; vomerine and palatine teeth large and clustered; pterygo-suspensorium covered internally with granules, passing into small conical teeth on the inferior margin of the bone; splenial with small conical teeth. The rays of all the fins robust and straight, not expanded, and only articulated for a relatively short extent distally; a double series of small, upwardly-pointing denticles on almost all the rays of the first dorsal and caudal fins; [supplementary caudal fin unknown]. Cranial roof-bones externally pitted and tuberculated; the other membrane-bones externally tuberculated, and the scales ornamented with elongated prickles.

The supplementary caudal fin in this genus is sometimes stated to be rudimentary or absent; but the condition of preservation of known specimens does not as yet justify a definite assertion.

Macropoma mantelli, Agassiz.

[Plate XIV. fig. 3.]

1822. *Amia? lewesiensis*, G. A. Mantell, Foss. South Downs, p. 239, pls. xxxvii., xxxviii.

1835. *Macropoma mantellii*, L. Agassiz, Poiss. Foss., Feuill. p. 55.

1844. *Macropoma mantellii*, L. Agassiz, *ibid.* vol. ii. pt. ii. p. 174, pl. lxv. *a(bis)–d.*

1849. *Macropoma mantelli*, W. C. Williamson, Phil. Trans. p. 462, pl. xlii. figs. 25, 26, pl. xliii. figs. 27–30.

1850. *Macropoma mantelli*, F. Dixon, Foss. Sussex, p. 368, pl. xxxiv. fig. 2.

1866. *Macropoma mantellii*, T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. xii. p. 27, pls. vii., viii.

1888. *Macropoma mantelli*, A. S. Woodward, Proc. Geol. Assoc. vol. x. p. 303.

Type. Fish; British Museum.

The type species, attaining a maximum length of about 0·55. Trunk robust but elongated; head and opercular apparatus occupying about one quarter of the total length; jugular plates about four times as long as broad. First dorsal fin large, consisting of not less than 8 robust rays; second dorsal relatively small, consisting of numerous slender rays; principal caudal fin comprising about 18–20 stout rays above and below. Mandible, post-maxillary, jugular plates, and operculum ornamented with numerous minute rounded tuberculations; parafrontals, postorbitals, and suborbitals pitted; tubercles of scales large, elongated, numerous, and closely arranged.

Although the specific name *lewesiensis* strictly pertains to this form, it seems advisable to employ the universally-adopted name of *mantelli* in honour of its discoverer.

Form. & Loc. Senonian and Turonian: S.E. England.

4219. Type specimen, figured by Mantell, *op. cit.* pl. xxxvii., and by Agassiz, *tom. cit.* pl. lxv. *a. bis*, fig. 1; Lewes, Sussex. *Mantell Coll.*

4253. Head and anterior abdominal region; the head figured *ibid.* pl. lxv. *a. bis*, fig. 2; Lewes. *Mantell Coll.*

4269. Abdominal region, showing portions of dorsal and pelvic fins, and well-preserved squamation, figured *ibid.* pl. lxv. *b*; Lewes. *Mantell Coll.*

4256. Portion of trunk showing air-bladder, much distorted, a small coprolite, the pelvic bones, and some of the pelvic fin-rays, figured *ibid.* pl. lxv. *c.* fig. 1; Lewes. *Mantell Coll.*

4264. Portion of jaws, figured *ibid.* pl. lxv. *c.* fig. 2; Lewes. *Mantell Coll.*

4251. Portion of head and abdominal region, the jugular plate,

angular, and inferior half of the clavicle of the right side figured *ibid.* pl. lxv. *c.* fig. 3; Lewes. The clavicle is shown from the inferior aspect, which is concave, as noted by Huxley, *loc. cit.* p. 33. *Mantell Coll.*

4298. Caudal fin-rays, figured *ibid.* pl. lxv. *c.* figs. 4, 5; Lewes. *Mantell Coll.*

4270. Head and anterior portion of trunk, showing air-bladder, figured *ibid.* pl. lxv. *d.* fig. 1; Lewes. The cluster of teeth on the supposed vomers is prominent; the left dentary is well preserved; and the left clavicle is described and figured by Huxley, *loc. cit.* p. 33, pl. vii. fig. 4 *b*. *Mantell Coll.*

4237. Head, seen from the right side, figured by Agassiz, *tom. cit.* pl. lxv. *d.* fig. 2, and by Huxley, *loc. cit.* pl. vii. fig. 3; Lewes. *Mantell Coll.*

4252. Head and abdominal region, the head figured by Agassiz, *tom. cit.* pl. lxv. *d.* fig. 3, and also described and figured by Huxley, *loc. cit.* p. 37, pl. vii. fig. 6; Lewes. *Mantell Coll.*

115. Imperfect head and trunk in counterpart; Halling, Kent. Portions of the fins and their supporting bones are shown, and the rays of the pectoral are described and figured by Huxley, *loc. cit.* p. 33, pl. vii. fig. 5 (wrongly quoted as no. 4258). *Purchased, about* 1836.

25782. Imperfect head and trunk, wanting all the fins except a portion of the principal caudal; Sussex. The head is figured by Dixon, *op. cit.* pl. xxxiv. fig. 2. The tuberculated surface of the jugular plates is noticed by Huxley, *loc. cit.* p. 38; and the operculum, angular, post-maxilla, frontals, and parietals are similarly ornamented. The upper half of the clavicle is shown, is quite smooth, and does not appear to have been exposed. *Dixon Coll.*

49834. Imperfect head and trunk, displaying the air-bladder elongated by crushing; New Pit, Lewes. The head exhibits the parafrontals, supposed maxilla, post-maxilla, angular and dentary bones; and the tuberculated operculum and jugular plates are also well shown. *Capron Coll.*

49836. Much crushed remains of head and trunk, displaying many of the bones, scales, and fin-rays; Lewes. The outer portion of the clavicle exhibits irregular longitudinal wrinkles. *Capron Coll.*

P. 2051. Imperfect head and trunk, with remains of the median fins; Sussex. *Egerton Coll.*

49887. Remains of head and fragment of abdominal region; Sussex. *Capron Coll.*

49833. Portions of head and abdominal region, with crushed remains of the air-bladder; North Stoke, near Arundel. Among the best preserved bones are the operculum, jugular plates, suborbital, dentary, and supposed maxilla. *Capron Coll.*

P. 4547. Imperfect head and anterior half of abdominal region, showing parts of the branchial apparatus noticed by Huxley, *loc. cit.* p. 39; near Maidstone. *Enniskillen Coll.*

47239. Imperfect head and abdominal region, and two portions of trunk; Grey Chalk, Dover. *Gardner Coll.*

35700. Portions of head and abdominal region; Grey Chalk, Dover. *Purchased*, 1859.

47240. Imperfect small head; Grey Chalk, Dover. *Gardner Coll.*

P. 3353. Head and opercular apparatus; Grey Chalk, Dover. *Enniskillen Coll.*

P. 3352. Skull and mandible described and figured by Huxley, *loc. cit.* p. 33, pl. viii., the specimen being only two-thirds as large as the figures; Sussex. *Enniskillen Coll.*

4245, 4247, 4289. Three imperfect heads, the third showing the basi-branchial bone; Sussex. *Mantell Coll.*

39070. Head with portions of the branchial and opercular apparatus and the left clavicle; Maidstone. The so-called maxilla and post-maxilla distinctly appear to be membrane-bones at the outer margin of the mouth. *Bowerbank Coll.*

49094. Large imperfect head, displaying the bones of the mandible. *Mrs. Smith's Coll.*

49837. Small, much crushed head and first dorsal fin; Dorking. *Capron Coll.*

P. 742. Three very imperfect heads; Lewes. *Egerton Coll.*

P. 4548. Imperfect large head, showing the post-maxilla and the superficial tuberculation both of that bone and the post-orbitals; English Chalk. *Enniskillen Coll.*

43851. Fragment of head, displaying the dentary and the apparent separation of an extremely-tuberculated infra-dentary element; Upper Chalk, Warne's Place, Rochester.
Purchased, 1872.

4246. Scattered remains of head, showing the inner aspect of the operculum, parietals, and the right pterygo-suspensorial, the latter noticed by Huxley, *loc. cit.* p. 36; Lewes.
Mantell Coll.

4238. Fragment showing parts of the branchial arches and the imperfect basi-branchial, inferior aspect; Lewes.
Mantell Coll.

28388. Similar specimen, showing also the inferior two-thirds of the clavicles and portions of the infraclavicles; Lewes. The infraclavicle (Pl. XIV. fig. 3, *i.cl*) is an elongated, slender bone, sharply bent at a point one third of its total length from the inferior extremity, and this third appears to consist of a triangular expansion in an almost horizontal plane; the upper two-thirds are of spatulate form overlapping the outer face of the lower end of the clavicle (*cl.*). The figure shows the right infraclavicle, outer and partly inferior aspect, restored in outline from evidence afforded by the element of the left side. *Mantell Coll.*

4260. Portion of abdominal region, with fragments of head, the air-bladder, first dorsal fin, and the basal bone of the second dorsal; Lewes. The basal bone of the first dorsal fin is noticed by Huxley, *loc. cit.* p. 38. *Mantell Coll.*

4216–17, 4221, 4236, 4241, 4243–44, 4250, 4258–59, 4261–62. Ten examples of the trunk, displaying various portions of the axial skeleton, the air-bladder, median fins, and scales; Lewes. Nos. 4216, 4241, and 4250 are preserved in counterpart, and the third exhibits, in transverse section, the longitudinal series of very large hollow spines occurring upon the middle of several horizontal rows of scales; the perforations are at first sight suggestive of the openings of sensory canals. Nos. 4236, 4250 show the distal articulation of the caudal fin-rays. *Mantell Coll.*

25789. Imperfect trunk exhibiting scales and portions of the median fins; Sussex. *Dixon Coll.*

25944. Imperfect trunk, showing an apparently lobate pelvic fin, noticed by Huxley, *loc. cit.* p. 33; Sussex. *Dixon Coll.*

25923 a. Fragments of abdominal and caudal region; Sussex. *Dixon Coll.*

41669. Fragments of trunk, showing the first dorsal fin, with its basal bone, and the ornamentation of spinelets upon the scales; Kent (?). *Toulmin-Smith Coll.*

P. 6287. Trunk with portions of the second dorsal, anal, and principal caudal fins.

43851 a. Specimen showing the basal bone of the first dorsal fin and some of the fin-rays; Upper Chalk, Warne's Place, Rochester. *Purchased*, 1872.

49096. Fragment of caudal region, with part of the principal caudal fin; Kent. *Mrs. Smith's Coll.*

49832, 49835. Two portions of trunk, the first showing well preserved scales, some with the large median spines, and exhibiting considerable variation in the ornamentation; Upper Chalk, Guildford. *Capron Coll.*

P. 6288. Small trunk with portions of the dorsal, principal caudal, and each of the pelvic fins.

P. 742 a. Fragment of trunk showing part of a pectoral fin, the lobe apparently covered with thin tuberculated scales; Sussex. *Egerton Coll.*

P. 5407. Fragment of trunk with well-preserved scales, exhibiting much variation in the ornamentation; Lewes. *Presented by P. E. Coombe, Esq.*, 1888.

P. 4638. Caudal region of very small individual, probably young of this species; Lewes. *Enniskillen Coll.*

4224–26, 4228, 4232–33. Portions of air-bladder; Lewes. *Mantell Coll.*

The Collection includes a large number of coprolites, the majority probably referable to *Macropoma*, though some may pertain to Elasmobranchs. The following series may be enumerated:—

4274, 4350, 4354. Three specimens noticed and figured by Mantell, Foss. S. Downs, pp. 103, 158, 310, pl. ix. figs. 3, 7, 10, as "supposed aments or cones of a species of Larch"; Lewes, Hamsey, and Steyning. *Mantell Coll.*

4332, 4338, 4334, 4276–77, 4319, 4275, 4273. Eight specimens,

described and figured by Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 177, pl. lx. *a. bis*, figs. 1–5, 7–11; Lewes.
Mantell Coll.

25792. The stouter of the two specimens figured by Dixon, Foss. Sussex, pl. xxx. fig. 33; Sussex. *Dixon Coll.*

49934. Crushed specimen; Lower Chalk, Southeram Pit, Lewes.
Capron Coll.

P. 5410. Five specimens; Lewes.
Presented by P. E. Coombe, Esq., 1888.

49929. Three small specimens; Upper Chalk, Guildford.
Capron Coll.

47258. Ten specimens; Grey Chalk, Dover. *Gardner Coll.*

35553. Portions of coprolites; Greensand, Tournay.
Presented by Thomas Davidson, Esq., 1859.

A species of *Macropoma* closely related to the typical *M. mantelli*, and not satisfactorily distinguished by the published diagnosis, is described as *Macropoma speciosum*, A. E. Reuss, Denkschr. k. Akad. Wiss. Wien, math.-naturw. Cl. vol. xiii. (1857), p. 33, pls. i., ii. The type specimen is a nearly complete fish, wanting the paired fins, from the Turonian of the Weissenberg, Bohemia, and is now preserved in the Royal Bohemian Museum, Prague. It is said to be distinguished from *M. mantelli* by the more slender form of the trunk, the number of the fin-rays, and the proportions of the pterygo-suspensorium ("infraorbital"); and a restoration is published by A. Fritsch (Rept. u. Fische böhm. Kreideform. 1878, p. 26, pl. iii.), partly based upon the type specimen, partly upon more recently discovered examples. The cranial osteology of the latter is criticized by O. M. Reis, Palæontographica, vol. xxxv. (1888), p. 63, pl. iv. fig. 2.

A second species of *Macropoma* in the Turonian of Bohemia is determined by Fritsch (*op. cit.* p. 31, pl. iv. figs. 2–7) under the name of *M. forte*. The type specimen, also from the Weissenberg, near Prague, is an imperfect head with opercular apparatus and some anterior scales, now preserved in the Royal Bohemian Museum; it is described as being characterized by scales relatively twice as large as those of *M. speciosum*, while the frontal bones are somewhat broader.

Doubtful scales from the Plänerkalk of Strehlen, near Dresden, are assigned to *Macropoma mantelli* by H. B. Geinitz, Foss. Fischschuppen Plänerkalk. Strehlen (1868), p. 47, pl. iv. figs. 8, 9, and Palæontographica, vol. xx. pt. ii. (1875), p. 218, pl. xliv. figs. 1, 2. The specimens are now in the Royal Museum, Dresden.

Suborder IV. *CLADISTIA.*

Notochord more or less constricted and replaced by ossified vertebræ. Baseosts in median fins rudimentary or absent; axonosts in regular series, equal in number to the apposed dermal fin-rays.

The di- or tri-basal character of the pectoral fins, in conjunction with other features, may perhaps justify the recognition of this group as a distinct order. It is represented only by the family of Polypteridæ (genera *Polypterus* and *Calamoichthys*), at present restricted to African rivers. No extinct types are known.

Order II. ACTINOPTERYGII.

Paired fins non-lobate, having an extremely abbreviated endoskeletal portion, and the dermal rays prominent; caudal fin abbreviate-diphycercal, heterocercal, or homocercal. A single paired series of transversely elongated rays, with or without an anterior azygous element, developed in the branchiostegal membrane between the mandibular rami.

DIVISION A.—*Pelvic fins with well-developed baseosts; median fins with dermal rays more numerous than the endoskeletal supporting elements; tail diphycercal or heterocercal. In the living forms—optic nerves not decussating but forming a chiasma, intestine with a spiral valve.*

Suborder I. *CHONDROSTEI.*

Notochord more or less persistent. Axonosts and baseosts of median fins in simple, regular series. Membrane-bones of pectoral arch comprising a pair of infraclavicular plates.

In all known members of this suborder there is a single dorsal and anal fin, well separated from the caudal.

Synopsis of Families.

A. Ascending Series.

Trunk elongate-fusiform; tail heterocercal; teeth slender, conical or styliform ..... PALÆONISCIDÆ (p. 424).

Trunk deeply fusiform; tail heterocercal; principal dentition on pterygoid and splenial bones, obtuse	PLATYSOMATIDÆ (p. 527).
Trunk elongate-fusiform; tail abbreviate-heterocercal; teeth slender, styliform.....	CATOPTERIDÆ (Part III.).
B. Degenerate Series. (See Part III.)	
Cranial shield without a median azygous series of bones; branchiostegal rays present; no teeth in adult; tail heterocercal; squamation rudimentary or absent, except on the upper caudal lobe	CHONDROSTEIDÆ.
Cranial shield without a median azygous series of bones; branchiostegal rays present; teeth in adult; tail diphycercal; longitudinal series of scutes upon trunk	BELONORHYNCHIDÆ.
Cranial shield with a median azygous series of bones; no branchiostegal rays; no teeth in adult; tail heterocercal; longitudinal series of scutes upon trunk....	ACIPENSERIDÆ.
Cranial shield with a median azygous series of bones; no branchiostegal rays; minute teeth in adult; tail heterocercal; squamation rudimentary or absent, except on the upper caudal lobe	POLYODONTIDÆ.

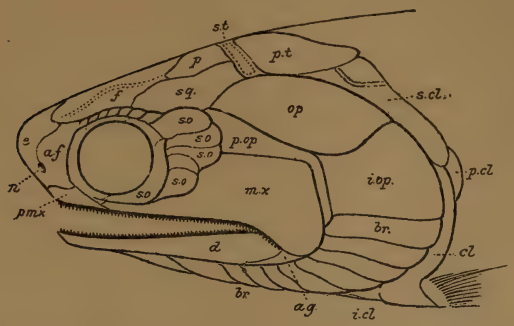
Family PALÆONISCIDÆ.

Trunk elongate or elongate-fusiform; tail heterocercal; scales rhombic (rarely in part cycloidal), ganoid. Head-bones well-developed, ganoid; no median series of cranial roof-bones; teeth slender, conical or styliform; eye far forwards and snout prominent; mandibular suspensorium more or less obliquely directed backwards and downwards. A series of broad branchiostegal rays, the most anterior pair especially large, with a small median element. Dorsal fin single and not much extended.

This is a somewhat comprehensive family, and it is not unlikely

that further researches may lead to its dismemberment. The most important contributions to present knowledge of the typical Palæozoic genera have hitherto been made by R. H. Traquair[1]; and the additional observations recorded in the following pages chiefly result from the study of Mesozoic forms.

Fig. 54.



Palæoniscus macropomus, Ag.—Head and pectoral arch, restored in outline, by R. H. Traquair.

a.f, anterior frontal; *a.g*, angular; *br*, branchiostegal rays; *cl*, clavicle; *d*, dentary; *e*, ethmoid; *f*, frontal; *i.cl*, infraclavicle; *i.op*, suboperculum; *mx*, maxilla; *n*, narial opening; *op*, operculum; *p*, parietal; *p.cl*, post-clavicle; *p.op*, preoperculum; *p.t*, post-temporal; *pmx*, premaxilla; *s.cl*, supraclavicle; *s.o*, circumorbital ring and suborbitals; *s.t*, supra-temporal; *sq*, squamosal.

No precise particulars are forthcoming as to the ossifications in the chondrocranium, but the dermal or membrane-bones of the head are conspicuous and well-known. The cranial roof is provided with a continuous shield, of which a small pair of parietals (fig. 54, *p*) and the flanking squamosal plates (*sq*) form the hinder portion, while a large pair of elongated frontals (*f*), with or without a separate pair of lateral plates, constitutes the middle portion; a large, azygous ethmoidal or rostral plate (*e*) completes the shield anteriorly, is flanked on each side by a so-called anterior frontal element (*a.f*), and with the latter surrounds the pair of narial openings (*n*). The base of the cranium also has the ordinary, well-developed parasphenoid membrane-bone. The jaws and cheek are likewise covered with

[1] Monogr. Palæont Soc. 1877; Quart. Journ. Geol. Soc. vol. xxxiii. (1877); and Trans. Roy. Soc. Edinb. vol. xxx. (1881, with plates in 1887). The Palæontographical Society's Monograph appears to have been abandoned, and has been replaced in recent years by numerous desultory notes without figures.

bony splints. The maxilla (*mx*) is a narrow, elongated element, much expanded behind the eye; the premaxilla (*pmx*) is comparatively small and insignificant. Surrounding the eye is a narrow ring of four thin bones (circumorbitals) bounded behind by others of the "suborbital" series (*s.o*); and the space between the latter, the cranial roof, maxilla, and opercular apparatus is covered by a single bent bone, interpreted by Traquair as preoperculum (*p.op*). In the mandible the articular portion of the meckelian cartilage is ossified, and the rest is ensheathed outside by a very large dentary (*d*) and a small angular (*ag*), while its inner face is equally covered by an extensive laminar splenial. Both the splenial and dentary, as a rule, bear teeth. The hyomandibular element of the suspensorium is well ossified superficially and is thus usually preserved, but no symplectic has been noticed; the former is much elongated, and somewhat bent at about the position of the lower border of the operculum. The pterygo-quadrate seems to be ossified at least at the quadrate articulation; and there is evidently a large, elongated membrane-bone ensheathing its inner or oral aspect. The operculum (*op*) is suspended from the hyomandibular, and is usually narrow, bounded below by a large suboperculum (*i.op.*), often with indications of a feebly developed interoperculum. Beneath the suboperculum, the opercular fold is strengthened by a series of lamelliform branchiostegal rays (*br*), which meets the corresponding series of the opposite side in front, and terminates in an anterior azygous element at the symphysial angle of the mandible. The branchial arches are sometimes seen to be ossified.

In the axial skeleton of the trunk, the notochord must have been persistent, and there is as yet no definite evidence of ossifications in its sheath. The neural arches and spines throughout the trunk, and the hæmal arches, with their spines in the caudal region, are superficially ossified, and are thus observed when there is no obscuring squamation; but there are no traces of ribs in any genus, the abdominal hæmal arches being merely small short pieces of cartilage. In the only genus in which they have been well displayed (*Coccolepis*), the neural spines are not fused with the supporting arches in the abdominal region, but both these and the hæmal spines are firmly fixed to their arches in the tail; at the base of the caudal fin the hæmals are much enlarged for the direct support of the dermal rays, while the neurals become gradually aborted, and there is a series of distinct supporting ossicles beneath the fulcra of the upper caudal lobe[1].

[1] The characters of the axial skeleton are to some extent shown in Ann. Mag. Nat. Hist. [6] vol. v. pl. xvi. figs. 2, 4; but more satisfactory information will appear in Mem. Geol. Surv. N.S. Wales, Palæont. no. 9, pls. i., ii.

It is not certain whether any narrow chain of supratemporal plates (fig. 54, *s.t*) is present behind the cranial shield; but there is a very large post-temporal (*p.t*) on each side, above the operculum and pectoral arch. The membrane-bones of the latter are all conspicuous and externally ornamented; the clavicle (*cl*) having a short inferior limb, and being bounded in front by a small triangular infraclavicle (*i.cl*); the supraclavicle (*s.cl*) deep and narrow, traversed above by the "lateral line," and bounded behind at its articulation with the clavicle by a small postclavicle (*p.cl*). Nothing is known of the scapulo-coracoid cartilage, but a small series of radials is sometimes seen at the base of the pectoral fin-rays. The basipterygium (axonost) of the pelvic fin has not yet been observed in any genus, probably on account of non-ossification; but the radial cartilages (baseosts) form a well-developed series of elongated elements in *Coccolepis australis*, and it is probable that thisis a common feature of the family. The dermal rays in all the fins are, as a rule, delicate, articulated, and bifurcated distally; a few genera only exhibiting simple rays, and some others having rays without articulation in the pectoral fin. In the median fins, the endoskeletal supports are always less numerous than the dermal rays, and they never appear to overlap the neural spines of the axial skeleton beneath. In some of the earlier types (e. g., *Elonichthys* and *Pygopterus*) these supports are distinctly shown in the dorsal fin to be arranged in two series—the proximal of slender axonosts, and the distal of stout baseosts; but in the Jurassic *Coccolepis* the baseost series seems to have completely disappeared. The dermal rays are to a slight extent imbricating, and the stouter portions are ordinarily coated more or less with ganoine.

The scales are typically rhombic, and united on the flanks by a peg-and-socket articulation; but in some genera (e. g., *Cryphiolepis* and *Coccolepis*) the overlap of the successive series is so extensive that they become essentially cycloidal, and the internal rib, with its articular facettes, disappears. All the scales are more or less coated with superficial ganoine, and the course of the lateral line is marked by a series of perforations, which terminate at the base of the upper caudal lobe. There is a dorsal and ventral series of azygous ridge-scales which are often enlarged, especially at the bases of the fins and upon the superior caudal lobe; and these are ordinarily continued by fulcra on the front margin of the fins. It is also worthy of note that the downward and backward trend of the scales is suddenly reversed at the base of the upper caudal lobe; and even when all the other scales are rudimentary or absent, the squamation of this lobe is always robust.

With regard to the arrangement of the genera of Palæoniscidæ, it must be remarked that the scheme adopted below is merely a provisional attempt to follow the lines of evolution. It may be regarded as tolerably well established that (i.) the obliquity of the suspensorium, (ii.) the loss of the baseosts in the median fins, (iii.) the advanced position of the dorsal fin, and (iv.) the increasing imbrication of the scales, are characters resulting from specialization. *Coccolepis*, in which all these features are combined, thus terminates the regular series.

Synopis of Genera.

A. Mandibular suspensorium nearly vertical; scales rhomboidal.
  I. Fin-rays dichotomous; caudal fin forked.
    Scales sculptured; a continuous series of enlarged ridge-scales; teeth minute ..... *Canobius* (p. 430).
    Scales smooth or in part faintly sculptured; teeth large, styliform, in regular close series; oral border of maxilla straight ..... *Gonatodus* (p. 434).
    As *Gonatodus*, but oral border of maxilla sharply deflected at the posterior expansion ..... *Drydenius* (p. 437).
    Scales smooth, or in part faintly sculptured; teeth minute..... *Amblypterus* (p. 437).
  II. Fin-rays simple; caudal fin obliquely truncated.
    Scales sculptured, some flank-scales very deep; teeth minute; fins small, with fulcra ..... *Eurylepis* (p. 448).
B. Mandibular suspensorium oblique.
  I. Fin-rays dichotomous; caudal fin forked.
    i. Dorsal fin remote, behind the anal.
      Scales minute; well-developed laniary teeth ..... *Cheirolepis* (p. 451).
    ii. Dorsal fin remote, not extending behind the anal; laniary teeth well-developed.
      Trunk elongated; anterior pectoral fin-rays articulated in distal third; scales small, finely striated, deep and narrow on flank, with prominent inner keel. *Nematoptychius* (p. 457).

Trunk elongated; anterior pectoral fin-rays articulated in distal third; dorsal and anal fins short-based; scales large, concentrically striated ..... *Cycloptychius* (p. 459).

Trunk fusiform; anterior pectoral fin-rays articulated distally; dorsal and anal fins short-based; scales large, obliquely striated.. *Rhadinichthys* (p. 461).

Trunk elongated; anterior pectoral fin-rays articulated distally; anal fin much extended; scales small, smooth or feebly striated. *Pygopterus* (p. 470).

Trunk elongated; dorsal and anal fins short-based; scales small, smooth or feebly striated .... *Trachelacanthus* (p. 475).

[Imperfectly defined.] Fins large and somewhat extended; scales obliquely striated ..... *Urolepis* (p. 475).

iii. Dorsal fin in advance of anal; dentition feeble.

Fins small, fulcra absent; scales of flank rudimentary or absent .. *Phanerosteon* (p. 476).

Fins small, fulcra minute; scales well-developed, with oblique sculpturing ..... *Palæoniscus* (p. 476).

Fins small, fulcra absent; scales very thin, with oblique sculpturing.. *Apateolepis* (p. 486).

Trunk much elongated; scales narrow and very thin..... *Actinophorus* (p. 486).

iv. Dorsal fin in advance of anal; laniary teeth well-developed.

Fins large, with fulcra; pectoral fin-rays all articulated; scales large or of moderate size, slightly overlapping, obliquely sculptured ..... *Elonichthys* (p. 487).

Fins large, with fulcra; pectoral fin-rays unarticulated (?); dorsal and anal fins short-based; scales large, thick, deeply overlapping, obliquely sculptured..... *Acrolepis* (p. 501).

Fins large, with fulcra; pectoral fin-rays unarticulated, except distally; anal fin much extended; operculum relatively narrow and deep; scales large, thick, well overlapping, obliquely sculptured ..... *Gyrolepis* (p. 510).

Fins large; pectoral fin-rays unarticulated, except distally; anal and pelvic fins extended; scales large, thick, slightly overlapping, obliquely sculptured; dorsal ridge-scales much enlarged.... *Atherstonia* (p. 514).

Fins large, fulcra minute; dorsal and anal fins short-based; scales very small, obliquely sculptured. *Myriolepis* (p. 515).

Fins large, fulcra minute; pectoral fin-rays unarticulated, except distally; dorsal and anal fins somewhat extended; scales small, thick, slightly overlapping, obliquely sculptured .... *Oxygnathus* (p. 516).

Fins large, with fulcra; pectoral fin-rays articulated; dorsal and anal fins short-based; scales of moderate size, thick, slightly overlapping, coarsely ridged and serrated ..... *Centrolepis* (p. 520).

Fins large, with fulcra; pectoral fin-rays articulated; dorsal and anal fins short-based; scales large, thin, very deeply overlapping, externally striated.... *Cryphiolepis* (p. 522).

Fins large, fulcra minute or absent; dorsal and anal fins short-based; scales large, thin, very deeply overlapping, externally tuberculated ..... *Coccolepis* (p. 523).

II. Fin-rays simple; caudal fin obliquely truncated.

Teeth minute; dorsal fin extended, not remote; scales sculptured, and dorsal ridge-scales much enlarged..... *Holurus* (p. 526).

Genus **CANOBIUS,** Traquair.

[Trans. Roy. Soc. Edinb. vol. xxx. 1881, p. 46.]

Trunk fusiform. Mandibular suspensorium nearly vertical; snout rounded, slightly projecting over the mouth; gape small [and teeth unknown]. Fin-rays articulated and distally bifurcating; fulcra minute. Dorsal and anal fins short-based, triangular-

acuminate, nearly opposite, the former arising only slightly in advance of the latter; caudal fin deeply cleft, inequilobate. Scales sculptured, somewhat deeper than broad on the anterior portion of the flank; a prominent series of dorsal ridge-scales.

Except in the characters of the head, there is much superficial resemblance between this genus and *Rhadinichthys*.

Canobius ramsayi, Traquair.

1881. *Canobius ramsayi*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 47, pl. v. figs. 1–4.

Type. Fish; Geological Survey of Scotland.

The type species, attaining a maximum length of about 0·08. Maximum depth of trunk contained about three times in the total length. Head and opercular apparatus occupying little more than one-fifth of the total length; snout very obtusely rounded; external bones ornamented with coarse flattened corrugations, except the mandible, which is marked by finer and nearly parallel longitudinal ridges. Pelvic fins relatively small, arising somewhat nearer to the anal than to the pectorals; dorsal and anal fins similar, almost completely opposed; caudal fin very heterocercal, the upper lobe being about twice as long as the lower, and nearly equalling one-third of the entire length of the fish. Scales comparatively smooth, rarely or never denticulated, but marked with few faint diagonal ridges and furrows, sometimes also with delicate vertical striæ close to and parallel with the anterior margin of the exposed area.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4068. Three typical specimens, one being in counterpart.
Purchased, 1883.

P. 5981. Trunk with median fins, in counterpart.
Purchased, 1889.

Canobius elegantulus, Traquair.

1881. *Canobius elegantulus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 49, pl. v. figs. 5–8.

Type. Fish; Geological Survey of Scotland.

General form and proportions as in the type species. Head and opercular bones ornamented with sharp, tortuous, and often

reticulating ridges. Scales marked with few prominent straight ridges, almost directly transverse, and terminating in acute denticulations on the hinder margin; also with few fine vertical striations close to and parallel with the anterior margin of the exposed area.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4069. Three well-preserved specimens. *Purchased*, 1883.

P. 5980. Specimen wanting paired fins. *Purchased*, 1889.

The three species defined below are now assigned by Traquair (Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 493) to a distinct genus, *Mesopoma*, "on account of the more typically Palæoniscid configuration of their facial bones." As, however, "the dentition is not yet ascertained in any of these forms, it seems also somewhat premature to proceed to the splitting of genera upon these distinctions" (Trans. Roy. Soc. Edinb. vol. xxx. p. 47).

Canobius pulchellus, Traquair.

1881. *Canobius pulchellus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 51, pl. v. figs. 9–13.
1890. *Mesopoma pulchellum*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 493.

Type. Fishes; Geological Survey of Scotland.

Length of head and opercular apparatus almost equal to the maximum depth of the trunk, which is contained slightly more than four and a half times in the total length. Cranial roof-bones tuberculated; facial bones ornamented with delicate ridges, usually flexuous, sometimes passing into tubercles. Scales ornamented with a few vertical ridges close to and parallel with the anterior margin, each reflexed below, and becoming directed backwards parallel to the inferior margin, while the remaining postero-superior area is occupied with ridges nearly parallel with the upper margin and terminating at the posterior border in denticulations.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4067. Specimen showing portions of all the fins except the pectorals. *Purchased*, 1883.

Canobius politus, Traquair.

1881. *Canobius politus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 53, pl. v. figs. 14–16.
1890. *Mesopoma politum*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 493.

Type. Imperfect fish; Geological Survey of Scotland.

General form and proportions as in *C. pulchellus*. Cranial roof-bones ornamented with coarse rugæ, more or less subdivided into elongated tubercles; facial bones striated. Scales very feebly ornamented with transverse, somewhat oblique ridges, in part terminating at the hinder border in denticulations; dorsal ridge-scales comparatively small.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4070. Two specimens. *Purchased*, 1883.

Canobius macrocephalus (Traquair).

1890. *Rhadinichthys macrocephalus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 398.
1890. *Mesopoma macrocephalum*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 493.

Type. Fish; collection of Dr. R. H. Traquair.

Trunk comparatively slender, the head with opercular apparatus occupying somewhat less than one quarter of the total length. Head-bones striated, the striæ upon the cranial roof being wavy and irregular, sometimes subdivided into tubercles. Scales feebly ornamented with oblique parallel ridges, terminating in denticulations at the hinder border; dorsal ridge-scales comparatively small.

Form. & Loc. Calciferous Sandstones; Midlothian.

41123. Specimen wanting the dorsal and pectoral fins; locality unknown. *Bryson Coll.*

Some doubtful fragmentary specimens from the Calciferous Sandstones (Cement-stone Group) of Blackadder Water, near Dunse, Berwickshire, are named *Canobius obscurus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. (1881), p. 68. [Geol. Survey of Scotland, Edinburgh.]

Genus **GONATODUS**, Traquair.

[Quart. Journ. Geol. Soc. vol. xxxiii. 1877, p. 555.]

Syn. *Microconodus*, R. H. Traquair, Ganoid Fishes Brit. Carb. Form. (Pal. Soc. 1877), p. 12 (name only).

Trunk fusiform. Mandibular suspensorium slightly oblique; teeth robust, styliform, more or less bent, forming a single, regular, close series on the margin of each jaw. Fins well developed, consisting of numerous robust, closely-jointed rays, distally branching; fulcra small. Base of pelvic fins short; dorsal and anal fins triangular, the former arising somewhat in advance of the latter; caudal fin forked. Scales large, smooth or feebly ornamented.

Gonatodus punctatus (Agassiz).

1835. *Amblypterus punctatus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 109, pl. iv. *c*. fig. 4 (*non* figs. 3, 5–8).

(?) 1872. *Amblypterus anconoechmodus*, R. Walker, Trans. Edinb. Geol. Soc. vol. ii. pt. i. p. 119, with plate.

1877. *Gonatodus punctatus*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 555, and Proc. Roy. Soc. Edinb. vol. ix. p. 265, and Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), pl. ii. figs. 4, 5.

1890. *Gonatodus punctatus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 391.

Type. Imperfect fish; Edinburgh Museum.

The type species, attaining a length of about 0·16. Maximum depth of trunk contained about three and a half times in the total length. Head and opercular apparatus small, triangular, occupying about one-fifth of the total length; external bones with sparse striations, often interrupted, those of the operculum and suboperculum transverse or obliquely directed downwards; dentition consisting of acutely pointed teeth, each inclined first a little inwards, then bent outwards at an obtuse angle, with the apex finally erect. Pelvic fins arising nearer to the anal than to the pectorals. Scales very large, ornamented with close, transverse, and partly concentric, striations, becoming feeble or absent in the caudal region; hinder border delicately serrated.

Form. & Loc. Calciferous Sandstone Series: Midlothian and Fifeshire.

P. 842. Well-preserved specimen, in counterpart, wanting the pectoral fins and part of the caudal; Wardie, near Edinburgh. *Egerton Coll.*

P. 3444. Much crushed specimen, displaying the pectoral fin, the ornamentation of some of the scales, head, and opercular bones, and the relatively large size of the operculum; Wardie. *Enniskillen Coll.*

42081. Hinder portion of maxilla; Anstruther, Fifeshire. *Purchased*, 1870.

Gonatodus macrolepis, Traquair.

[Plate XVI. fig. 8.]

1877. *Gonatodus macrolepis*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 556, and Proc. Roy. Soc. Edinb. vol. ix. p. 271.

Type. Fish; Edinburgh Museum.

Trunk somewhat more elongated than in the type species, the maximum depth contained not less than four times in the total length. Head and opercular bones striated, the striæ more or less interrupted and branching on the cranial roof and facial bones; teeth large and obtusely pointed, nearly equal in both jaws. Scales very large, almost or entirely smooth; those of the anterior part of the flank with feeble traces of striæ close to and parallel with the anterior and inferior margins, and the hinder border delicately serrated.

Form. & Loc. Carboniferous Limestone (Blackband Ironstone): Gilmerton, near Edinburgh, and (?) Possil, near Glasgow.

P. 843, P. 843 a. Two typical specimens, with displaced squamation, showing portions of all the fins, and the first also exhibiting some of the teeth of both jaws; Gilmerton. The dentition is shown, of four times the natural size, in Pl. XVI. fig. 8. *Egerton Coll.*

P. 3441. Much crushed specimen measuring 0·18 in length; Gilmerton. *Enniskillen Coll.*

Gonatodus parvidens, Traquair.

[Plate XVI. fig. 7.]

1882. *Gonatodus parvidens*, R. H. Traquair, Geol. Mag. [2] vol. ix. p. 546.

Type. Fish; Edinburgh Museum.

Maximum depth of trunk contained somewhat less than four times in the total length. Head and opercular bones ornamented

with striæ passing into rounded, elongated tuberculations on the cranial roof; teeth of relatively small size on the maxilla. Scales nearly smooth, those of the anterior part of the flanks with few, irregular, delicate rugæ close to and parallel with the anterior and inferior borders, and sparse pittings on the rest of the exposed surface; hinder border not serrated.

Form. & Loc. Middle Carboniferous Limestone (Edge-Coal Series): Midlothian and Fifeshire. Carboniferous Limestone: Lanarkshire.

P. 3443. Well-preserved specimen displaying all the fins, shown, of the natural size, in Pl. XVI. fig. 7; Wallyford, near Edinburgh. The head exhibits the dorso-lateral aspect, and the bones are seen only as impressions of their external surface. The fins consist of broad, longitudinally ribbed rays, closely articulated and distally branching; and there are prominent fulcra. The pelvic fins are somewhat inferior in size to the pectorals, and even the foremost rays of the latter are distinctly articulated. The dorsal and anal fins are about equal in size, and the latter arises opposite the hindermost rays of the former. The upper lobe of the tail is wanting distally, but the caudal fin is well preserved and exhibits its bifurcation. Except upon the upper caudal lobe, the scales are all displaced, but their general proportions are recognizable.

Enniskillen Coll.

P. 839, P. 1008. Four specimens; Lochgelly, Fifeshire.

Egerton Coll.

P. 3434, P. 3442. Four specimens: Lochgelly. *Enniskillen Coll.*

P. 4799. Imperfect fish; Blackband, Possil, near Glasgow.

Armstrong Coll.—Transferred from Edinburgh Museum, 1884.

The following species are of uncertain generic position:—

Gonatodus brainerdi, J. S. Newberry, Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 125, pl. xxxiv. figs. 1, 2: *Palæoniscus brainardi*, J. S. Newberry, Amer. Journ. Sci. [2] vol. xxxiv. (1862), p. 78 (name only): *Palæoniscus brainerdi*, J. S. Newberry (*ex* Thomas), Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 346.—Berea Grit (Lower Carboniferous); Ohio. [Columbia College, New York.]

Gonatodus molyneuxi, R. H. Traquair, Geol. Mag. [3] vol. v.

(1888), p. 252; J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. (1890), p. 178, pl. vi. fig. 11: *Microconodus molyneuxi*, R. H. Traquair, Ganoid Fishes Brit. Carb. Form. (Pal. Soc. 1877), p. 33 (name only).—Coal-Measures (Deep-mine Ironstone Shale); Longton. [Collection of J. Ward, Esq.]

Gonatodus (?) *toilliezi*, L. G. de Koninck, Faune Calc. Carb. Belg. pt. i. (1878), p. 11, pl. i. figs. 1, 2: *Palæoniscus*, P. J. Van Beneden, Bull. Acad. Roy. Sci. Belg. [2] vol. xxxi. (1871), p. 515.—Upper Carboniferous Limestone; Viesville, Belgium. [Caudal and posterior abdominal region: University of Louvain.]

The following genus and species is stated to differ only from *Gonatodus* in the downward extension of the posterior expanded portion of the maxilla, and in the relatively large size of the splenial teeth:—

Drydenius insignis, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. (1890), p. 399.—Carboniferous Limestone (Blackband Ironstone); near Edinburgh. [Imperfect fish; Edinburgh Museum.]

Genus **AMBLYPTERUS**, Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1833, pp. 3, 28.]

Syn. *Leiolepis*, F. Goldenburg, Fauna Saræpontana Fossilis, 1873, p. 5.

Trunk deeply fusiform; mandibular suspensorium only slightly oblique; teeth minute. Fins large or of moderate size, with minute fulcra, the rays distally bifurcating; dorsal partly in advance of, partly opposing the anal; caudal fin powerful. Scales smooth, except sometimes in the anterior portion of the abdominal region, where they are more or less striated in their hinder half and serrated.

This genus is adopted as amended by Troschel and Traquair. The species placed first in Agassiz's description (*Palæoniscum macropterum* of Bronn) does not agree with the published diagnosis in the nature of its dentition, and *Amblypterus latus* is thus regarded as the type species. The striking resemblance between the scales of this fish and those of the Palæoniscidæ of Autun now assigned to *Amblypterus*, was already pointed out by Agassiz, *tom. cit.* p. 38.

Amblypterus latus, Agassiz.

1833. *Amblypterus latus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 4, 37, pl. iv. figs. 2–6.

1833. *Amblypterus lateralis*, L. Agassiz, *ibid.* pp. 4, 39, pl. iv. figs. 1, 7–9. [Strassburg Museum.]

1857. *Amblypterus latus*, F. H. Troschel, Verhandl. naturh. Verein. preuss. Rheinlande u. Westphalens, p. 13, pl. ii. fig. 17.

1877. *Amblypterus latus*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 552, and Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), pl. ii. fig. 1.

1877. *Amblypterus lateralis*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 552.

Type. Nearly complete fishes ; Strassburg Museum.

The type species. Trunk regularly fusiform, the caudal pedicle being short and robust; dorsal contour much arched, and maximum depth in advance of the dorsal fin contained slightly more than three times in the total length. Head and opercular apparatus small, scarcely occupying one quarter of the total length ; external bones striated. Fins relatively large, the pelvic pair smaller than the pectorals, arising midway between the latter and the anal; dorsal and anal fins longer than deep, the dorsal arising behind the middle point of the back, and the anal opposed to its hinder two thirds. Scales large and smooth, those of the middle of the flank not much deeper than broad.

The sole differences between this species and the so-called *A. lateralis* seem to the present writer to be due to differences of age and the state of preservation. There are sparse striations upon the head-bones of all well-preserved specimens, and no constant difference in the proportions of the scales can be observed in the collection recorded below.

Form. & Loc. Lower Permian : Rhenish Prussia.

22658. Crushed remains of an adult individual, about 0·18 in length, in counterpart; Lebach. *Purchased*, 1848.

22658 a. Well-preserved specimen, in counterpart, showing the subdivision of each series of scales at the base of the dorsal fin into two series ; Lebach. *Purchased*, 1848.

29006. A fine example in counterpart, measuring 0·16 from the extremity of the snout to the base of the upper caudal lobe; Lebach. The squamation and portions of the fins are well shown. *Purchased*, 1859.

P. 979, P. 3458. Two well-preserved specimens in counterpart, and the greater portion of a large individual with traces of the fine dentition ; Lebach.

Egerton & Enniskillen Colls.

15415, 15415 a. Two imperfect specimens in counterpart, the first about 0·11 in total length and displaying all the fins except the extremity of the caudal; Börschweiler and Lebach. *Purchased*, 1843.

P. 978. Imperfectly preserved small individual; Börschweiler. *Egerton Coll.*

32577, 36128. Two small specimens, the first in counterpart; Lebach. *Purchased*, 1857, 1860.

P. 359, P. 979 a. Two small specimens, the second labelled by Agassiz; Lebach. *Egerton Coll.*

P. 980, P. 3459. Two small specimens, in counterpart, one half of the second labelled *A. lateralis*, and the other half both *latus* and *lateralis*, in Agassiz's handwriting; Lebach. *Egerton & Enniskillen Colls.*

P. 3459 a. Small imperfect specimen, in counterpart, labelled *A. lateralis* by Agassiz; Lebach. *Enniskillen Coll.*

28487. Well-preserved remains of a very small individual, in counterpart; Saarbrück. *Purchased*, 1853.

Amblypterus traquairi, sp. nov.

[Plate XV. fig. 2.]

Type. Imperfectly preserved fish; British Museum.

Trunk regularly fusiform, the caudal pedicle robust, and the dorsal contour not much arched; maximum depth contained about four times in the total length. Head and opercular apparatus occupying one quarter of the total length; external bones coarsely striated. Fins relatively large, the pelvic pair scarcely smaller than the pectorals, arising midway between the latter and the anal; dorsal and anal fins longer than deep, the dorsal arising at about the middle point of the back, and the anal opposed to its hinder two thirds. Scales relatively large, apparently all smooth.

Form. & Loc. Lower Permian: Rhenish Prussia.

P. 994, P. 3457. Type specimen 0·2 in length, preserved in counterpart, and shown, about three-quarters nat. size, in Pl. XV. fig. 2; Lebach. The bones of the head are much scattered, but the outlines of some are distinct. *Egerton & Enniskillen Colls.*

P. 994 a, P. 3457 a. Smaller individual, in counterpart, wanting part of the head and the extremity of the tail; Lebach. *Egerton & Enniskillen Colls.*

P. 980 a, P. 3459 a. Small specimen, in counterpart, obliquely crushed, and labelled *Amblypterus lateralis* by Agassiz; Lebach. *Egerton & Enniskillen Colls.*

Amblypterus duvernoyi (Agassiz).

1833. *Palæoniscus duvernoy*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 4, 45, 103, pl. vii.
1834. *Palæoniscus vratislaviensis*, L. Agassiz, *ibid.* p. 60, pl. x. figs. 1, 2, 4–6.
1834. *Palæoniscus lepidurus*, L. Agassiz, *ibid.* p. 64, pl. x. figs. 3, 7, 8, 9.
1848. *Amblypterus duvernoy*, C. G. Giebel, Fauna der Vorwelt, Fische, p. 252.
1848. *Palæoniscus vratislaviensis*, C. G. Giebel, *ibid.* p. 247.
1851. *Palæoniscus gibbus*, F. H. Troschel, Verhandl. naturh. Verein preuss. Rheinlande u. Westphalens, p. 523, pl. ix.
1851. *Palæoniscus dimidiatus*, F. H. Troschel, *ibid.* p. 528, pl. x.
(?) 1851. *Palæoniscus tenuicauda*, F. H. Troschel, *ibid.* p. 532, pl. xi.
(?) 1851. *Palæoniscus elongatus*, F. H. Troschel, *ibid.* p. 536, pl. xii.
1851. *Palæoniscus opisthopterus*, F. H. Troschel, *ibid.* p. 538, pl. xiii.
1857. *Palæoniscus duvernoyi*, F. H. Troschel, *ibid.* p. 16.
1861. *Palæoniscus rohani*, J. J. Heckel, Denkschr. k. Akad. Wiss., math.-naturw. Cl. vol. xix. p. 51, pls. i.–iii. [Royal Bohemian Museum, Prague.]
1861. *Palæoniscus obliquus*, J. J. Heckel, *ibid.* p. 56, pl. v. [Ibid.]
1861. *Palæoniscus caudatus*, J. J. Heckel, *ibid.* p. 58, pl. vi. [Ibid.]
1861. *Palæoniscus vratislaviensis* and *lepidurus*, H. B. Geinitz, Dyas, pp. 18, 19.
1861. *Palæoniscus blainvillei*, H. B. Geinitz (*errore*), *ibid.* p. 19, pl. ix. fig. 3.
1864. *Palæoniscus vratislaviensis*, E. Weiss, Zeitschr. deutsch. geol. Gesell. vol. xvi. p. 274, woodcut.
1877. *Amblypterus duvernoyi*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 558.
1877. *Amblypterus wratislaviensis*, R. H. Traquair, *ibid.* p. 558.
1877. *Amblypterus lepidurus, dimidiatus, elongatus, tenuicauda, gibbus, opisthopterus, rohanni, obliquus*, and *caudatus*, R. H. Traquair, *ibid.* p. 558.

Type. Two nearly complete fishes; Palæontological Museum, Munich, and *olim* H. G. Bronn Collection.

Trunk deep in the abdominal region, and the caudal pedicle produced; the back much arched in advance of the dorsal fin, the

greatest depth of the trunk equalling about one quarter of the total length of the fish. Head and opercular apparatus small, occupying about one-fifth of the total length; external bones striated, the striæ upon the cranial roof being coarse, irregular, and more or less subdivided. Paired fins small, the pelvic pair placed slightly nearer to the anal than to the pectorals; dorsal and anal fins equal in size, triangular and short-based, the dorsal arising behind the middle of the back, and the anal opposed to its hinder half. Scales large, those of the middle of the flank somewhat deeper than broad; a few series immediately behind the clavicle exhibiting fine posterior flutings and denticulations.

As pointed out by Giebel and Traquair, this species is truly referable to *Amblypterus*; and the other so-called species of *Palæoniscus*, here regarded as synonyms, have also been assigned to *Amblypterus* by Traquair. The type specimens were obtained from the black shales of Kreuznach, and it appears to the present writer that the various forms named by Troschel from the same formation and locality owe their supposed distinctive features merely to differences in crushing and state of preservation. The latter series has already been identified with "*Palæoniscus*" *vratislaviensis* by Weiss, who gives an elaborate table of measurements to show the great variation in the proportions of typical examples of *P. vratislaviensis* from Ruppersdorf, Bohemia. As a rule the last-mentioned specimens do not attain so large a size as those from Kreuznach; but there are intermediate forms, and the examples from Münster Appel assigned by Agassiz to *P. duvernoyi* are almost equally small.

The so-called *Palæoniscus minutus*, Agassiz (Poiss. Foss. vol. ii. pt. i. pp. 4, 47, pl. viii. figs. 1–3), from Münster Appel, of which the type is in the Strassburg Museum, is probably the young of this species. It is provisionally assigned to *Amblypterus* by Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 558.

A very large imperfect fish from the Lower Permian of Semil, Bohemia, described under the name of *Palæoniscus luridus* (J. J. Heckel, Denkschr. k. Akad. Wiss., math.-naturw. Cl. vol. xix. 1861, p. 54, pl. iv.), is also difficultly distinguishable from *Amblypterus duvernoyi*; the specimen is in the Royal Bohemian Museum, Prague.

Form. & Loc. Lower Permian: Rhenish Bavaria and Bohemia.

37775–76. Two typical large specimens in black shale, of unknown locality; one larger than Agassiz's second type specimen, and the other exhibiting well-preserved scales and median fins. *Purchased*, 1863.

P. 981. Small imperfect specimen, labelled *Palæoniscus gibbus*, Troschel; Sobernheim, near Kreuznach. *Egerton Coll.*

P. 3467. Similar specimen; Sobernheim. *Enniskillen Coll.*

P. 3464. More satisfactorily preserved fish, of the form named *P. dimidiatus*, Troschel; Sobernheim. *Enniskillen Coll.*

P. 983. An imperfectly preserved individual, extended during fossilization, of the form named *P. tenuicauda*, Troschel; Sobernheim. *Egerton Coll.*

P. 982. Small specimen, resembling the so-called *P. opisthopterus*, Troschel; Sobernheim. *Egerton Coll.*

P. 985 a. Somewhat smaller but similar specimen, labelled *P. duvernoyi* by Agassiz; Moersfeld. *Egerton Coll.*

20665–66. Two small specimens, one wanting head; Moersfeld. *Purchased*, 1846.

28615. Small individual in similar matrix; Moersfeld. *Dixon Coll.*

P. 984–5. Seven small examples; Moersfeld and Zweibrücken, near Münster Appel. Some of these and the next specimens are labelled by Agassiz, and are noticed in the Poiss. Foss. vol. ii. pt. i. p. 103. *Egerton Coll.*

P. 3465–66, P. 4352. Four similar specimens: Moersfeld and Zweibrücken. *Enniskillen Coll.*

P. 987. Very young individual, wanting head: Münster Appel. *Egerton Coll.*

20663–64. Three imperfect examples of the trunk, wanting the head, two being as large as the first of the type specimens; Ottendorf, Bohemia. *Purchased*, 1846.

P. 988–9. Two small specimens, one in a very similar state of preservation to the so-called *P. lepidurus*, Agassiz; Ottendorf. *Egerton Coll.*

P. 3471. Typical specimen: Oelberg, near Braunau, Bohemia. *Enniskillen Coll.*

P. 3471 a. Smaller example; said to have been obtained from Braunau. *Enniskillen Coll.*

877. Trunk of typical "*Palæoniscus vratislaviensis*," wanting head; Ruppersdorf, Bohemia. *Purchased*, 1837.

1229. Similar specimen, with fragments of the head; Ruppersdorf. *Purchased*, 1837.

20662. Six small examples, variously crushed: Ruppersdorf. *Purchased*, 1846.

23405. Imperfect fish, shortened by crushing; Ruppersdorf. *Purchased*, 1849.

36591. Trunk, wanting head; Ruppersdorf. *Dixon Coll.*

38158. Six specimens, three being only slightly crushed; Ruppersdorf. *Presented by Sir Roderick I. Murchison, K.C.B.*, 1864.

P. 991. Three specimens, one originally measuring about 0·16 in length and identical with the Rhenish examples in form and proportions; Ruppersdorf. *Egerton Coll.*

P. 6289. Elongated specimen; Ruppersdorf. *Purchased.*

P. 3470. Four small fishes, two appearing relatively slender; Ruppersdorf. *Enniskillen Coll.*

38158 a. Three small specimens; Ruppersdorf. *Presented by Sir Roderick I. Murchison, K.C.B.*, 1864.

Amblypterus beaumonti (Egerton).

1850. *Palæoniscus beaumonti*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. vi. p. 6, pl. i. figs. 5, 6.

1877. *Amblypterus beaumonti*, R. H. Traquair, *ibid.* vol. xxxiii. p. 558.

Type. Imperfect head and trunk, wanting fins; British Museum.

A large species, attaining a length of not less than 0·35. Trunk regularly fusiform, the dorsal margin arched in advance of the dorsal fin, and the maximum depth contained about four times in the total length. Head with opercular apparatus occupying somewhat less than one quarter of the total length; external bones marked with coarse vermiculating rugæ. Pelvic fins nearly as large as the pectorals, arising midway between the latter and the anal; dorsal arising about the middle of the back, immediately behind the pelvic fins, relatively small, short-based, and triangular, almost completely in advance of the anal, which equals it in size and form. Scales large, those of the middle of the flank slightly deeper than broad; dorso-lateral scales smooth, with non-serrated posterior margins; ventro-lateral scales with few posterior serra-

tions, those immediately behind the pectoral arch also marked with short oblique striæ terminating in the serrations.

Form. & Loc. Lower Permian: Autun, France.

P. 3418. Type specimen. *Enniskillen Coll.*

P. 3419. Well-preserved small trunk, with fins, noticed by Egerton, *loc. cit.* *Enniskillen Coll.*

P. 986, P. 3417. Partially scattered remains of large trunk and median fins, in counterpart. *Egerton & Enniskillen Colls.*

P. 3417 a. Smaller imperfect trunk and fins. *Enniskillen Coll.*

Amblypterus decorus (Egerton).

1850. *Palæoniscus decorus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. vi. p. 7, pl. ii.

1877. *Amblypterus decorus*, R. H. Traquair, *ibid.* vol. xxxiii. p. 558.

Type. Fish with imperfect head; British Museum.

A large species, attaining a length of not less than 0·25. Form and proportions of head, trunk, and fins as in *A. beaumonti*; external bones similarly ornamented with vermiculating rugæ. Scales all smooth, without posterior serrations, except feeble traces in the anterior ventro-lateral region; principal scales of flank scarcely deeper than broad.

Form. & Loc. Coal-Measures: Commentry, Allier, France; Harz Mts.

P. 607, P. 3420. Type specimen, being a fish wanting the greater portion of the caudal region, but completely shown in the counterpart impression; Commentry. *Egerton & Enniskillen Colls.*

28293. Dorsal half of abdominal region and the caudal pedicle; Commentry. *Purchased*, 1851.

P. 3422. Imperfectly preserved fish wanting the extremity of the tail, compared with this species by Egerton, *loc. cit.* p. 7; Ilfeld, Harz. *Enniskillen Coll.*

Amblypterus arcuatus (Egerton).

1850. *Palæoniscus arcuatus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. vi. p. 7, pl. i. fig. 1.

1877. *Amblypterus arcuatus*, R. H. Traquair, *ibid.* vol. xxxiii. p. 558.

Type. Head and abdominal region; British Museum.

An imperfectly known species of moderate size. Trunk robust; dorsal margin gently arched in advance of dorsal fin. Head-bones marked with coarse vermiculating ridges; teeth of mandible in regular close series, very slender. Dorsal fin arising opposite the hinder portion of the pelvic pair. Scales relatively smaller and thicker than those of *A. decorus*, scarcely deeper than broad on the middle of the flank, those of the anterior ventro-lateral region feebly crenulated and serrated.

Form. & Loc. Permian: Prussia.

P. 3461. Type specimen, displaying the mandibular teeth; Goldlauter. *Enniskillen Coll.*

P. 3462. More imperfect, larger head and abdominal region; Goldlauter. *Enniskillen Coll.*

Amblypterus reussi (Heckel).

1861. *Palæoniscus reussii*, J. J. Heckel, Denkschr. k. Akad. Wiss., math.-naturw. Cl. vol. xix. p. 61, pl. vii.

1877. *Amblypterus reussii*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 558.

Type. Nearly complete fish; Royal Bohemian Museum, Prague.

Trunk short and deep, the maximum depth in advance of the dorsal fin contained about three and a half times in the total length. Head and opercular apparatus occupying less than one quarter of the total length; external bones marked with fine striæ and rugæ. Pelvic fins well developed, inserted halfway between the pectorals and the anal; dorsal arising behind the middle of the back, high, triangular, and short-based, directly opposed to the slightly smaller anal. Scales large, those of the middle of the flank deeper than broad; all smooth, except two or three anterior series, which exhibit delicate flutings and crenulations at the free margin.

Form. & Loc. Lower Permian: Semil, Bohemia.

Not represented in the Collection.

Amblypterus blainvillei (Agassiz).

1818. *Palæothrissum inæquilobum*, H. D. de Blainville, Nouv. Dict. d'Hist. Nat. vol. xxvii. p. 321 (imperfectly defined).

1818. *Palæothrissum parvum*, H. D. de Blainville, *ibid.* p. 321 (imperfectly defined).

1833. *Palæoniscus blainvillei*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 4, 48, pl. v.

839. *Palæoniscus blainvillei*, Landriot, Compte-Rendu Soc. Eduenne, vol. i. p. 122, pl. fig. 2.
1877. *Amblypterus* (?) *blainvillei*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 558.

Type. Nearly complete fishes; Strassburg Museum.

Trunk short and deep, the maximum depth immediately in advance of the dorsal fin contained nearly three and a half times in the total length. Head and opercular apparatus relatively small, occupying less than one quarter of the total length; external bones marked with fine striæ and rugæ. Pelvic fins well developed, inserted halfway between the pectorals and the anal; dorsal arising about the middle of the back, relatively small, short-based, and triangular, completely in advance of the anal, which equals it in size and form. Scales large, those of the middle of the flank nearly twice as deep as broad, all smooth and not crenulated.

Form. & Loc. Lower Permian; Muse, near Autun.

36051. Well-preserved specimen, 0·115 in length, wanting the extremity of the upper caudal lobe.
Presented by S. P. Pratt, Esq., 1857.

41908. Slab of shale with remains of several individuals.
Purchased, 1870.

P. 996–7. Various fragmentary specimens, some perhaps referable to the next species. *Egerton Coll.*

P. 3469. Slab of shale with remains of three or four individuals, and four other specimens. *Enniskillen Coll.*

Amblypterus voltzi (Agassiz).

1833. *Palæoniscus voltzii*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 5, 55, 83, pl. vi., pl. D. fig. 1.
1839. *Palæoniscus voltzii*, Landriot, Compte-Rendu Soc. Eduenne, vol. i. p. 122, pl. fig. 1.
1877. *Amblypterus* (?) *voltzii*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 558.

Type. Nearly complete fishes; Strassburg Museum and Museum of Natural History, Paris.

A species closely related to *A. blainvillei*, but described as characterized by its somewhat more elongated shape, the relatively larger size of the head and scales, and the smoothness of the operculum.

Form. & Loc. Lower Permian: Muse, near Autun.

33991–92. Small individual, wanting head, and the caudal region of another specimen, probably of this species.
Presented by Sir Roderick I. Murchison, K.C.B., 1860.

The following specimens are of the form named *Palæoniscus angustus* by Agassiz, Poiss. Foss. vol. ii. pt. i. (1833), pp. 4, 57, pl. ix. figs. 1–5[1]; but it is still uncertain whether they may not be the young of *A. voltzi*. They are provisionally assigned to *Amblypterus* by Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 558.

P. 990. Obscurely preserved specimen, exhibiting a short regular series of slender conical teeth; Muse, near Autun.
Egerton Coll.

P. 3475. A more satisfactorily preserved trunk, with imperfect head; Muse. *Enniskillen Coll.*

The following specimens may pertain to *Amblypterus*, as here defined, but do not suffice for exact determination:—

P. 6290. Small fish, wanting the greater part of the head and paired fins; Lower Permian, Kostialov, Bohemia. *Purchased.*

P. 5564. Smaller fish, with imperfect head; Lower Permian, Nyřan, Bohemia. *Purchased*, 1888.

P. 995. Fish 0·125 in length, with imperfect fins; Coal-Measures, Commentry, Allier, France. *Egerton Coll.*

P. 1013. Imperfect larger specimen, noticed by Egerton, Quart. Journ. Geol. Soc. vol. vi. p. 8; Coal-Measures, Liège, Belgium. *Egerton Coll.*

The following species have also been described, but there are no examples in the Collection:—

Amblypterus costatus: *Palæoniscus costatus*, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1583, pl. lv. fig. 10.—Permian; Kargala, Govt. of Orenburg, Russia.

Amblypterus gelberti, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. (1877), p. 558 : *Palæoniscus gelberti*, Goldfuss, Beitr. vorweltl. Fauna Steinkohlengeb. (1847), p. 17, pl. iv. figs. 4–6.—Lower Permian; Heimkirchen, near Kaiserslautern. [University of Bonn.]

Amblypterus (?) *nanus* : *Palæoniscus nanus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, 1857, pt. ii. p. 350, and Leth.

[1] Specimens from the Lower Permian of Hohenelbe are also assigned to this species by H. B. Geinitz, Dyas, p. 20, pl. x. figs. 2, 3.

Rossica, vol. i. (1860), p. 1586, pl. lv. fig. 12.—Permian; Kargala.

Amblypterus tuberculatus: *Palæoniscus tuberculatus*, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, 1857, pt. ii. p. 349, and Leth. Rossica, vol. i. (1860), p. 1585, pl. lv. fig. 11. —Ibid. [University of St. Petersburg.]

Some fishes from the Lower Permian of Moravia, said to be related to the species from France and Bohemia here assigned to *Amblypterus*, bear the undefined names of *Palæoniscus katholitzkianus*, *P. moravicus*, and *P. promptus* (A. Rzehak, Verhandl. k.-k. geol. Reichsanst. 1881, p. 79).

The so-called *Amblypterus orientalis* (E. von Eichwald, Leth. Rossica, vol. i. 1860, p. 1588, pl. lv. fig. 15), possibly identical with the imperfectly defined *Tetragonolepis murchisoni* (G. Fischer de Waldheim, Bull. Soc. Imp. Nat. Moscou, 1842, p. 463), is of doubtful genus, the type specimen being a portion of squamation, with remains of median fins, from the Permian of Kargala, Govt. of Orenburg, Russia. *Amblypterus ornatus*, E. Emmons (Manual Geol. ed. 2, 1860, p. 183, fig. 161, nos. 1–3), from the Chatham Series of North Carolina, is also founded upon indeterminable Palæoniscid scales.

Amblypterus olfersi, L. Agassiz, Poiss. Foss. vol. ii. pt. i. (1833), pp. 4, 40, from the Upper Cretaceous of Brazil, was subsequently recognized by the same author as referable to the Physostomous bony fish *Rhacolepis* (*ibid.* vol. ii. pt. ii. 1844, p. 283).

Genus **EURYLEPIS**, Newberry.

[Proc. Acad. Nat. Sci. Philad. 1857, p. 150.]

Syn. *Mecolepis*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. 1856, p. 96 (preoccupied).

Trunk fusiform. Mandibular suspensorium nearly vertical; snout rounded; gape small, and teeth numerous, short, and conical. Fins relatively small, with delicate fulcra; fin-rays robust, not branching, but merely attenuated distally. Dorsal and anal fins short-based, triangular-acuminate, nearly opposite, the former arising only slightly in advance of the latter; caudal fin obliquely truncated or exhibiting very slight excavation. Scales smooth or with feeble ornament, often serrated; two or more series of flank-scales not less than twice as deep as broad.

The species of this genus are all of very small size, and have only been discovered hitherto in a thin seam of cannel-coal in the Coal-Measures at Linton, Ohio.

Eurylepis tuberculata, Newberry.

1856. *Mecolepis tuberculatus*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. p. 96.

1873. *Eurylepis tuberculatus*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. p. 350, pl. xxxviii. figs. 2, 3.

Type. Fish; Columbia College, New York.

The type species, attaining a maximum length of about 0·08. Length of head with opercular apparatus about equal to the maximum depth of the trunk, and occupying one-fourth of the total length of the fish. Cranial roof-bones ornamented with large rounded rugæ and tuberculations, facial bones with finer corrugations. Scales smooth, denticulated in the abdominal region; anterior scales of principal series nearly five times as deep as broad.

Form. & Loc. Coal-Measures: Linton, Ohio.

P. 1005. Three specimens labelled by Dr. Newberry. *Egerton Coll.*

P. 3449. Two specimens and one in counterpart, labelled by Dr. Newberry. *Enniskillen Coll.*

Eurylepis granulata, Newberry.

1856. *Mecolepis granulatus*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. p. 97.

1856. *Mecolepis insculptus*, J. S. Newberry, *ibid.* p. 97. [Columbia College, New York.]

1873. *Eurylepis granulatus*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. p. 352, pl. xxxix. fig. 5.

1873. *Eurylepis insculptus*, J. S. Newberry, *ibid.* p. 351, pl. xxxix. fig. 2.

Type. Fish; Columbia College, New York.

General proportions as in the type species. Cranial roof-bones ornamented with sharp corrugations and occasional intervening granulations. Scales comparatively thin, more or less rugose and tuberculated in the anterior part of the abdominal region, with a faint double waved line along the anterior margin, and fine posterior serrations; foremost scales of principal lateral series about four times as deep as broad.

Form. & Loc. Coal-Measures: Linton, Ohio.

P. 1007. Two well-preserved specimens. *Egerton Coll.*

P. 3450. Similar specimen, labelled *E. granulatus* by Dr. Newberry. *Enniskillen Coll.*

A form of *Eurylepis*, apparently distinguished from *E. granulata* merely by the extension of the scale-ornament over the caudal region, is named *E. ornatissima*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 352, pl. xxxix. fig. 4 (= *Mecolepis ornatissimus*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. 1856, p. 97). Three other species are also determined as enumerated below, the type specimens being nearly complete fishes in the Museum of Columbia College, New York:—

Eurylepis corrugata, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 350, pl. xxxviii. fig. 4: *Mecolepis corrugatus*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. 1856, p. 96 (adopted as type of *Mecolepis*).

Eurylepis (?) *lineata*, J. S. Newberry, *ibid.* 1873, p. 353, pl. xxxix. fig. 7: *Mecolepis lineatus*, J. S. Newberry, *ibid.* 1856, p. 97: *Rhadinichthys* (?) *lineatus*, J. S. Newberry, Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 228.

Eurylepis striolata, J. S. Newberry, *tom. cit.* 1873, p. 355.

The small fish from the Coal-Measures of Linton, Ohio, named *Mecolepis serratus*, J. S. Newberry (Proc. Acad. Nat. Sci. Philad. vol. viii. 1856, p. 97), does not appear to have been mentioned since the original notice.

The following specimens appear to the present writer to be specifically indeterminable immature individuals:—

P. 998. Two small fishes of the form named *Eurylepis ovoidea*[1], from Linton. *Egerton Coll.*

P. 1006. Three small fishes of the form named *Eurylepis minima*[2], from Linton. *Egerton Coll.*

P. 3451. Four similar specimens. *Enniskillen Coll.*

Another genus of stout proportions, with nearly vertical suspensorium, now assigned to the Palæoniscidæ, is *Benedenichthys*, R. H. Traquair (Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 492), originally defined under the pre-occupied name of *Benedenius* (Traquair, in L. G. de Koninck, Faune Calc. Carb. Belg. pt. i. 1878,

[1] J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. (1873), p. 351, pl. xxxix. fig. 1: *Mecolepis ovoideus*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. 1856, p. 97.

[2] J. S. Newberry, *ibid.* 1873, p. 353, pl. xxxix. fig. 3.

p. 14). There are no examples in the Collection, and the following is the only recognized species :—

Benedenichthys deneensis, R. H. Traquair, Faune Calc. Carb. Belg. pt. i. (1878), p. 16, pl. ii., and Trans. Roy. Soc. Edinb. vol. xxix. (1879), p. 354, pl. iii. fig. 17 (*Benedenius*): *Palæoniscus deneensis*, P. J. Van Beneden, Bull. Acad. Roy. Belg. vol. xxxi. (1871), p. 512, pl. iv.—Carboniferous Limestone : Denée, Belgium. [Imperfect fish ; University of Louvain.]

Genus **CHEIROLEPIS**, Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1835, p. 128.]

Trunk elongated and gradually tapering from the maximum depth at or immediately behind the pectoral arch. Mandibular suspensorium oblique; dentition consisting of an inner series of large, well-spaced conical teeth, with an outer series of numerous very small teeth; head and opercular bones ornamented with striations, irregular rugæ, or elongated tubercles. Fins of moderate size, consisting of numerous very delicate rays, articulated and branching; fulcra prominent, and the ridge-scales of the upper caudal lobe distinctly divided into two halves at the apex. Pelvic fins with extended base-line; dorsal fin scarcely longer than deep, the anal elongated, and the former not arising in advance of the origin of the latter; upper caudal lobe short and stout, the fin inequilobate and only slightly forked. Scales minute, relatively thick, and coated with ganoine, having an internal vertical rib, not overlapping.

The most elaborate description of *Cheirolepis*, with numerous figures, is that of Pander, published in 1860[1]; and additional observations, with corrections, were subsequently contributed by Traquair[2]. By Pander the genus was regarded as representing a peculiar family, Cheirolepidæ, afterwards adopted by Huxley[3]; but the researches of Traquair seem to justify its being assigned to the Palæoniscidæ.

[1] C. H. Pander, Ueber die Saurodipt., Dendrodont., Glyptolepid., u. Cheirolepid. devon. Syst. (1860), pp. 69–73.

[2] R. H. Traquair, Ann. Mag. Nat. Hist. [4] vol. xv. (1875), pp. 237–249, pl. xvii.

[3] T. H. Huxley, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv. 1861), dec. x. pp. 38–40.

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Cheirolepis trailli, Agassiz.

1828. 'Second Gamrie Ichthyolite,' Pentland, Trans. Geol. Soc. [2] vol. ii. p. 364.
1835. *Cheirolepis traillii*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 130, pl. i. *d*, pl. i. *e*. fig. 4.
1835. *Cheirolepis uragus*, L. Agassiz, *ibid.* p. 132, pl. i. *e*. figs. 1–3[1].
1844. *Cheirolepis cummingiæ*, L. Agassiz, *ibid.* p. 301 (name only).
1844. *Cheirolepis cummingiæ*, L. Agassiz, Poiss. Foss. V. G. R. p. 45, pl. xii. [Forres Museum.]
1848. *Chirolepis curtus*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 302. [Woodwardian Museum.]
1848. *Chirolepis macrocephalus*, F. M'Coy, *ibid.* p. 303. [Ibid.]
1848. *Chirolepis velox*, F. M'Coy, *ibid.* p. 302. [Ibid.]
1855. *Chirolepis traillii*, F. M'Coy, Brit. Palæoz. Foss. p. 581.
1855. *Chirolepis uragus*, F. M'Coy, *ibid.* p. 581.
1855. *Chirolepis curtus*, F. M'Coy, *ibid.* p. 580, pl. ii. D. fig. 1.
1855. *Chirolepis macrocephalus*, F. M'Coy, *ibid.* p. 580, pl. ii. D. fig. 3.
1855. *Chirolepis velox*, F. M'Coy, *ibid.* p. 581, pl. ii. D. fig. 2.
1860. *Chirolepis curtus* = *C. cummingiæ*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xvi. p. 123.
1860. *Chirolepis macrocephalus* = *C. trailli*, Sir P. Egerton, *ibid.* p. 123.
1867. *Cheirolepis trailli*, J. Powrie, Geol. Mag. vol. iv. p. 152.
1867. *Cheirolepis cummingiæ*, J. Powrie, *ibid.* p. 152.
1867. *Cheirolepis uragus*, J. Powrie, *ibid.* p. 152.
1875. *Cheirolepis cummingiæ*, R. H. Traquair, Ann. Mag. Nat. Hist. [4] vol. xv. p. 240, pl. xvii.
1888. *Cheirolepis trailli*, R. H. Traquair, Geol. Mag. [3] vol. v. p. 517.
1890. *Cheirolepis trailli*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 485.

Type. Imperfect fishes ; *olim* T. S. Traill Collection.

The type species, attaining a length of about 0·35. Maximum depth of trunk contained about five and a half times in the total length. Head slightly longer than deep, the head with opercular apparatus occupying one-fifth of the total length ; facial and opercular bones coarsely striated, the striæ on the circumorbitals radiating, those on the expansion of the maxilla chiefly horizontal, though somewhat reticulated behind, and those of the operculum obliquely directed downwards and backwards. Pelvic fins relatively low and small, arising somewhat nearer to the anal than to the pectorals ; dorsal and anal fins equally elevated, the former about two-thirds as long as the latter, and arising slightly behind the origin of this fin ; all the larger joints of the fin-rays sculptured

[1] Under this name fragments from near Pawlowsk, Govt. of St. Petersburg, are described by E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1575, pl. lvii. fig. 21.

with fine marginal pectinations. Scales very small, with fine, short, marginal pectinations in their antero-superior portion.

Form. & Loc. Lower Old Red Sandstone: Orkney, Caithness, Ross-shire, Nairnshire, Cromarty, and Banffshire.

(i.) Orkney (typical *C. trailli*).

35045. Obscurely preserved fish, with impressions of fins, the bones and scales converted into a shining bituminous substance; Stromness. *Purchased*, 1860.

39187. Smaller example with distinct remains of dentition and ornamented squamation. *Bowerbank Coll.*

40969. Specimen 0·26 in length, similar to the first in state of preservation; Stromness. *Purchased*, 1867.

P. 171–5. Five similarly-preserved specimens, the third only 0·17 in length and in counterpart. *Purchased*, 1881.

P. 1367. Two similar specimens showing the greater portion of the squamation and fins in impression; Belyacreugh. *Egerton Coll.*

(ii.) Ross-shire.

41731. Imperfect trunk with well-preserved squamation and remains of the fins; Glen Roy. *Purchased*, 1869.

P. 6077. Remains of the head, pectoral arch, and abdominal region; probably from Edderton, near Tain. The coarsely rugose ornament of the clavicle and supraclavicle is displayed. *Presented by F. Harford, Esq.*, 1889.

P. 1174. Caudal region, imperfectly preserved; Edderton. *Egerton Coll.*

(iii.) Lethen Bar, Nairnshire (typical *C. cummingiæ*).

49182. Imperfectly-preserved fish, in counterpart, 0·25 in length, showing all the fins. *Purchased*, 1878.

49193. Similar specimens displaying some of the teeth and branchiostegal rays. *Purchased*, 1878.

P. 2073, P. 3402. Similar specimen, in counterpart, 0·3 in length, with nearly complete caudal fin, showing its inequilobate form and slightly excavated posterior border. *Egerton & Enniskillen Colls.*

P. 3403. Head and much distorted trunk, ventral aspect. The jaws and branchiostegal rays are well shown, and are described and figured by Traquair, *loc. cit.* (1875), p. 246, pl. xvii. fig. 1. *Enniskillen Coll.*

41725, P. 5597. Imperfect head and abdominal region, ventral aspect, in counterpart. The left maxilla, the mandible, branchiostegal rays, infraclavicles, and the left pectoral fin are well shown; and of these the branchiostegal rays and infraclavicles are noticed by Traquair, *loc. cit.* (1875), pp. 244, 246. *Purchased*, 1869, 1888.

28867. Small head and trunk, much crushed, wanting the caudal fin and part of the dorsal and anal fins.
Purchased, 1854.

P. 739, P. 1370, P. 1370 a. Two imperfect heads, two portions of head and trunk, and an example of the caudal region. The first specimen is seen in impression, showing distinct traces of the row of minute teeth in the mandible, and exhibiting the striated, partly rugose, and tuberculated character of the facial bones and the clavicle. The circumorbital ring, so far as preserved, shows a radiated ornamentation. In the second example of the head, the maxilla and the narrow cheek-plate above it are well shown. *Egerton Coll.*

21547. Trunk having all the fins well preserved. The total length of the base of the dorsal fin is about 0·026, while that of the anal is not less than 0·04, and the length of the front margin of each is approximately 0·03. The anterior border of the pectoral fins also measures 0·03 in length, and that of the pelvic fins about 0·015. The base-line of the pelvic fins is much extended, and the caudal fin is distinctly inequilobate.
Presented by Norman McLeod, Esq., 1847.

21547 a. Larger and more imperfectly preserved caudal region.
Presented by Norman McLeod, Esq., 1847.

(iv.) Cromarty.

19805. Remains of small head and trunk, showing jaws.
Purchased, 1845.

(v.) Tynet Burn, Banffshire.

35777. Much crushed small fish, about 0·175 in length, with well-preserved caudal lobe and fin. *Purchased*, 1860.

35984. Small contorted fish, with displaced head and opercular bones. The left maxilla exhibits the coarse, horizontal striation of its expanded portion. *Purchased*, 1861.

36060-61. Another small fish, in counterpart, wanting the caudal fin. *Purchased*, 1861.

39181. Slightly larger specimen, wanting the caudal fin. The inner aspect of the left clavicle and the characters of the pectoral fins are well shown; and immediately behind the upper part of the clavicle there are indications of irregularly enlarged scales. *Bowerbank Coll.*

37384. Much crushed fish, about 0·3 in length, showing part of the cranial roof with the pair of longitudinal sensory canals. The operculum and suboperculum of one side are displaced behind the pectoral arch, the operculum being very narrow and deep and marked by oblique, backwardly and downwardly directed striations. *Purchased*, 1863.

41310. Fine specimen, distorted on the ventral aspect of the head and abdominal region. The cranial roof exhibits the pair of longitudinal sensory canals, as noted by Traquair, *loc. cit.* (1875), p. 236; and there are remains of the large cheek-plate above the maxilla. The operculum is very deep and narrow, and apparently ornamented with striations or fine rugæ obliquely directed backwards and downwards; and the suboperculum seems to be broader than deep. Immediately behind the pectoral arch there are four enlarged series of scales, gradually decreasing to the normal size; and the change of the squamation upon the upper caudal lobe is obvious. The elongation of the anal fin described in No. 21547 is again conspicuous; and the caudal fin is complete, showing the slight excavation of the posterior border and the inequality of the lobes. *Purchased*, 1869.

P. 342, P. 1370 b. Two specimens, about 0·25 and 0·28 in length, the second very imperfectly preserved. *Egerton Coll.*

P. 4345. Somewhat distorted small fish, displaying the pectoral, anal, and caudal fins, and the double fulcra of the upper caudal lobe. *Enniskillen Coll.*

35778, 35983. Two portions of nodules with crushed remains of the head and part of the trunk. *Purchased*, 1860–61.

36035. Small trunk with well-preserved fins, wanting the caudal pedicle and fin and the greater part of the head.
Purchased, 1861.

(vi.) Gamrie, Banffshire.

The following specimens are preserved in rough, coarse-grained nodules, in the same condition as the type of *Cheirolepis uragus* :—

19428. Two very imperfect small fishes, the first showing parts of the pectoral and anal fins, the second in counterpart, and both wanting the dorsal and caudal fins.
Purchased, 1845.

28862. Comparatively well-preserved fish, about 0·29 in length.
Purchased, 1854.

19805 a. Imperfect remains of head and trunk, ventro-lateral aspect, showing branchiostegal rays and the paired fins.
Purchased, 1845.

P. 3404. Some scattered bones of the head and scales.
Enniskillen Coll.

P. 6291. Caudal pedicle and fin.

The following specimens are more satisfactorily preserved, occurring in fine-grained compact nodules:—

47866. Much-crushed specimen, in counterpart, with remains of all the fins. *Purchased*, 1877.

P. 4049. Imperfect, much-crushed head and trunk, in counterpart, displaying the inner aspect of the right clavicle and the infraclavicles, and the internal stout rib upon the scales.
Purchased, 1883.

P. 4050–52. Three fine specimens, in counterpart, exhibiting most of the principal characters of the fish, the second attaining a length of 0·33. The sculpturing of the scales and fin-rays is especially well shown in the first specimen.
Purchased, 1883.

P. 5072. Typical specimen, wanting paired fins.
Presented by John Edward Lee, Esq., 1885.

Cheirolepis canadensis, Whiteaves.

1881. *Cheirolepis canadensis,* J. F. Whiteaves, Canadian Naturalist, n. s., vol. x. p. 33.

1889. *Cheirolepis canadensis,* J. F. Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 90, pl. viii.

Type. Imperfect fish; Geological Survey of Canada, Ottawa.

A larger species than the type, closely similar in proportions, but differing in the more advanced position of the pelvic fins and the more remote situation of the dorsal. Scales and joints of fin-rays pectinated.

Form. & Loc. Upper Devonian: Scaumenac Bay, P. Q., Canada. Not represented in the Collection.

Some of the scales described as follows may also pertain to fishes allied to the preceding, but they must be regarded as indeterminable:—

Cheirolepis splendens, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xvii. (1844), p. 830, and *ibid.* vol. xix. (1846), pt. ii. p. 304, pl. x. figs. 24, 25, and Leth. Rossica, vol. i. (1860), p. 1573, pl. lvii. fig. 23.—Devonian; Marjina, near Pawlowsk.

Cheirolepis unilateralis, E. von Eichwald, *tom. cit.* (1844), p. 830, and *tom. cit.* (1846), pt. ii. p. 305, pl. x. figs. 26, 27, and *tom. cit.* (1860), p. 1574, pl. lvii. fig. 14.—Ibid. and River Ischora.

Microlepis exilis, E. von Eichwald, *tom. cit.* (1844), p. 830, and *tom. cit.* (1846), pt. ii. p. 303, pl. x. figs. 22, 23, and *tom. cit.* (1860), p. 1576, pl. lvii. fig. 12.—Devonian; River Ischora.

Microlepis lepida, E. von Eichwald, *tom. cit.* (1844), p. 830, and *tom. cit.* (1846), pt. ii. p. 302, pl. x. figs. 20, 21, and *tom. cit.* (1860), p. 1576, pl. lvii. fig. 13.—Devonian; Marjina. [The type species.]

Genus **NEMATOPTYCHIUS,** Traquair.

[Ann. Mag. Nat. Hist. [4] vol. xv. 1875, p. 259.]

Trunk elongated. Mandibular suspensorium very oblique; dentition in each jaw consisting of an inner sparse row of stout, conical, laniary teeth, and an outer close series of small conical teeth; external bones striated and tuberculated. Paired fins of moderate size, median fins large; fin-rays stout, distally birfurcating, closely articulated, except in the proximal two-thirds of those forming the

anterior part of the pectoral fins; fulcra minute. Dorsal and anal fins not excessively elongated, remote, almost or completely opposed to each other. Scales small, very slightly imbricating, and externally striated; those of the flank deep and narrow, with relatively large peg-and-socket articulation.

Nematoptychius greenocki, Traquair.

1844. *Pygopterus greenockii*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 78 (undefined).
1866. *Pygopterus greenockii*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. v. p. 597.
1867. *Pygopterus greenockii*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxiv. p. 701, pl. xlv.
1872. *Pygopterus elegans*, C. W. Peach, Rep. Brit. Assoc. 1871, Trans. Sect. p. 109 (name only). [Edinburgh Museum.]
1875. *Nematoptychius greenockii*, R. H. Traquair, Ann. Mag. Nat. Hist. [4] vol. xv. p. 258, pl. xvi. figs. 7–11.
1877. *Nematoptychius gracilis*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix. p. 262. [Collection of Dr. R. H. Traquair.]
1877. *Nematoptychius greenockii*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 577, and Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), pl. i. figs. 7–11.
1879. *Nematoptychius greenockii*, R. H. Traquair, Proc. Roy. Phys. Soc. Edinb. vol. v. pp. 118, 128.
1890. *Nematoptychius greenockii*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. pp. 391, 398.

Type. Imperfect fish; Edinburgh Museum.

Maximum depth of trunk contained more than five times in the total length; dorsal contour of abdominal region scarcely arched. Head elongated, small, and snout pointed; head and opercular apparatus occupying nearly one quarter of the total length; maxilla ornamented by striæ parallel to the hinder and upper margins, passing into irregular tuberculations near the alveolar border; dentary bone externally tuberculated or irregularly rugose. Pelvic fins well developed, arising midway between the pectoral pair and the anal. Dorsal and anal fins similar in form, somewhat longer than high, the dorsal slightly smaller than the anal and arising immediately in front of the latter. Scales externally ornamented with very fine, wavy ridges, sometimes branching and anastomosing, directed obliquely downwards.

Form. & Loc. Calciferous Sandstone Series: Midlothian and Fifeshire. Carboniferous Limestone Series: Midlothian and Lanarkshire.

P. 3445. Head, opercular apparatus, and some anterior scales, preserved in counterpart; Calciferous Sandstone, Wardie, near Edinburgh. The maxilla, dentary, operculum, suboperculum, branchiostegal rays, and some other bones, are well shown from the inner aspect. *Enniskillen Coll.*

P. 846. Similar head, in counterpart, with the imperfectly preserved abdominal region; Wardie. Portions of the external ornament are seen on some of the bones. *Egerton Coll.*

19815. Fragment of squamation; Wardie. *Purchased*, 1845.

50094. Remains of jaws; Calciferous Sandstone, Burdiehouse, near Edinburgh. *Purchased*, 1879.

50088. Fragments of dentary bone; Calciferous Sandstone, Grange Quarry, Burntisland, Fifeshire. *Purchased*, 1879.

P. 846 a, P. 3440. Portion of trunk, with dorsal and anal fins, in counterpart; Burntisland. *Egerton & Enniskillen Colls.*

45867. Group of head-bones and scales, associated with similar remains of *Eurynotus crenatus*, noticed by R. H. Traquair, Ann. Mag. Nat. Hist. [4] vol. xv. (1875), p. 258; Burntisland. *Presented by W. Carruthers, Esq.*, 1874.

P. 847. Scattered remains of head and scales, especially displaying the mandible; Carboniferous Limestone (Edge Coal Series), neighbourhood of Edinburgh. *Egerton Coll.*

P. 4338. Similar group of remains, displaying the maxilla; Carboniferous Limestone (Edge Coal Series), Wallyford, near Edinburgh. *Enniskillen Coll.*

Genus **CYCLOPTYCHIUS**, Young.

[Rep. Brit. Assoc. 1865 (1866), p. 318.]

Trunk narrow and elongated. Mandibular suspensorium oblique; teeth in two series, a small outer row and larger, well-spaced laniaries within. Fins of moderate size, with distinct fulcra, and the rays distally bifurcating; principal rays of pectoral fin unarticulated except distally; dorsal and anal fins triangular, short-based, almost or completely opposed; upper caudal lobe slender, and caudal fin deeply forked. Scales large, ornamented with ridges chiefly concentric with the margins.

Cycloptychius carbonarius, Young.

1866. *Cycloptychius carbonarius*, J. Young (*ex* Huxley, MS.), Rep. Brit. Assoc. 1865, p. 319.
1868. *Cycloptychius*, Hancock & Atthey, Ann. Mag. Nat. Hist. [4] vol. i. p. 362.
1873. *Cycloptychius*, T. P. Barkas, Coal Meas. Palæont. p. 36, fig. 140.
1874. *Cycloptychius carbonarius*, R. H. Traquair, Geol. Mag. [2] vol. i. p. 241, pl. xii.
1875. *Cycloptychius carbonarius*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 240.
1875. *Cycloptychius*, W. J. Barkas, Monthly Rev. Dental Surgery, vol. iii. p. 500, figs. lxviii.–lxx.
1890. *Cycloptychius carbonarius*, J. Ward, Trans. N. Staffs. Inst. Mining Engineers, vol. x. p. 179, pl. iv. figs. 3–5.

Type. Imperfect fishes; collection of J. Ward, Esq., Longton.

The type species, attaining a maximum length of about 0·17. Trunk very slightly tapering to the dorsal and anal fins, more rapidly contracted beyond; dorsal margin not arched. Head and opercular apparatus occupying about one-fifth of the total length; cranial roof-bones rugose and tuberculated, the facial and opercular bones with irregular, more or less concentric and parallel striations. Dorsal and anal fins equal and opposite, as high as long, arising at somewhat less than three-fifths of the total length from the extremity of the snout; pelvic fins arising midway between the pectorals and the anal. All the scales ornamented with sharp ridges parallel with the anterior, inferior, and posterior borders; principal scales of flank not more than one and a half times as deep as broad, the postero-inferior angle slightly rounded.

Form. & Loc. Coal-Measures: North Staffordshire and Northumberland.

P. 5175–6. Two individuals 0·12 and 0·11 in length, the first being in counterpart and wanting the pectoral fins, the second showing only a trace of these fins; Deep-mine Ironstone Shale, Longton, N. Staffordshire. *Purchased*, 1885.

P. 1011. More imperfectly preserved individual; Deep-mine Ironstone Shale, Longton. *Egerton Coll.*

P. 1011 a. Imperfect trunk displaying the squamation; Bassey-mine Ironstone Shale, Longton. *Egerton Coll.*

P. 3447. Well-preserved fish, wanting the pectoral and caudal fins, counterpart of specimen figured in the Geol. Mag. [2] vol. i. pl. xii. fig. 1; Deep-mine Ironstone Shale, Longton. *Enniskillen Coll*

P. 3447 a, b, P. 4333. A much-crushed specimen wanting the end of the tail, portions of head and abdominal region, in counterpart, and two imperfect examples of the caudal region; Deep-mine Ironstone Shale, Longton.
Enniskillen Coll.

36899. Imperfect head displaying some of the teeth, and a few anterior flank-scales; Longton. *Purchased*, 1862.

39918. Imperfect small individual displaying some of the branchiostegal rays; Longton. *Purchased*, 1866.

Cycloptychius concentricus, Traquair.

1881. *Cycloptychius concentricus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 37, pl. ii. figs. 17–20.

Type. Fishes; Geological Survey of Scotland.

Form and proportions as in the type species; facial bones and opercular apparatus striated, the mandible being slender and tapering, with a narrow band of tuberculations along its upper margin, and the striæ below arranged diagonally. Scales ornamented with few large rounded ridges parallel with the anterior, inferior, and posterior borders; principal scales of flank slightly more than one and a half times as deep as broad, with much rounded postero-inferior angle; scales near dorsal margin almost equilateral, with only one or two concentric ridges, the inner area being marked with few short diagonal ridges.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4063. Somewhat elongated individual, in counterpart, showing all the fins. *Purchased*, 1883.

P. 4064–66. Three more imperfectly preserved specimens, the first in counterpart, and all displaying parts of the squamation. *Purchased*, 1883.

Genus **RHADINICHTHYS,** Traquair.

[Quart. Journ. Geol. Soc. vol. xxxiii. 1877, p. 559.]

Trunk elegantly fusiform, more or less elongated. Mandibular suspensorium very oblique; teeth in two series, a small outer row and larger, incurved, conical laniaries, well spaced, within. Fins

of moderate size, consisting of delicate rays, distally bifurcated, with an anterior series of slender fulcra; principal rays of pectoral fin unarticulated except near their distal extremity. Dorsal and anal fins triangular, partly or completely opposed; upper caudal lobe slender, and caudal fin deeply forked, unsymmetrical. Scales large or of moderate size, more or less delicately sculptured; ridge-scales in advance of dorsal fin much enlarged.

Rhadinichthys ornatissimus (Agassiz).

1835. *Palæoniscus ornatissimus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 92, pl. x. *a*. figs. 6, 8 (*non* figs. 5, 7).
1877. *Rhadinichthys ornatissimus*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 559, and Proc. Roy. Soc. Edinb. vol. ix. p. 432.
1877. *Rhadinichthys lepturus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix. p. 437. [Imperfect fish; Edinburgh Museum.]
1890. *Rhadinichthys ornatissimus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. pp. 391, 397.

Type. Imperfect fish; Edinburgh Museum.

The type species, attaining a length of about 0·25. Head with opercular apparatus occupying about one-fifth of the total length; greatest depth of trunk immediately behind the operculum, and tail-pedicle narrow. Head-bones finely and closely striated. Paired fins small, the pectoral about one half as long as the head; dorsal fin arising slightly in front of the anal, shorter than the latter, both these fins with much excavated posterior margins. Scales of flank relatively large, somewhat deeper than broad. Scale-ornament consisting of sharp, delicate striæ, mostly parallel with the superior and inferior margins, sometimes sigmoidally curved, with punctures in the intervening furrows; posterior margin serrated.

Form. & Loc. Calciferous Sandstones: Midlothian and Fifeshire.

P. 3439. An imperfectly preserved fish wanting the head, and an imperfect caudal region; Burdiehouse, near Edinburgh.
Enniskillen Coll.

P. 1000. Remains of small trunk; Granton, near Edinburgh.
Egerton Coll.

41129. Imperfect small fish; (?) Burntisland, Fifeshire.
Bryson Coll.

Rhadinichthys carinatus (Agassiz).

1835. *Palæoniscus carinatus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 104, pl. iv. *c*, figs. 1, 2.
1877. *Rhadinichthys geikiei*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix. p. 438. [Geological Survey of Scotland.]
1877. *Rhadinichthys carinatus*, R. H. Traquair, *ibid.* p. 441, and Quart. Journ. Geol. Soc. vol. xxxiii. p. 559.
1890. *Rhadinichthys carinatus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. pp. 391, 397.

Type. Imperfect fish; Edinburgh Museum.

Trunk slender, the head occupying somewhat more than one-fifth of the total length to the bifurcation of the caudal fin. Head-bones ornamented with sharp, delicate, wavy striæ. Median fins relatively large, the dorsal arising slightly in advance of the anal, and the latter as long as deep; fin-rays smooth. Scales of flank large, almost equilateral, a few short oblique striæ extending from some of the denticulations of the hinder border, and others, still more delicate, parallel with the inferior border.

Form. & Loc. Calciferous Sandstones: Midlothian and Fifeshire.

P. 844. Fish imperfectly preserved in nodule; Wardie, near Edinburgh. *Egerton Coll.*

42082. Head and anterior abdominal region; Anstruther, Fifeshire. *Purchased*, 1870.

Rhadinichthys brevis, Traquair.

1877. *Rhadinichthys brevis*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix. p. 440.

Type. Fish; collection of Dr. R. H. Traquair.

A species of short and stout proportions, attaining a length of about 0·12. Bones of cranial roof ornamented with vermiculating flattened rugæ, facial and opercular bones with finer striæ. Paired fins relatively small; median fins well developed, the dorsal and anal almost completely opposed. Scales of flank nearly equilateral; posterior border exhibiting five or six prominent oblique denticulations. Scale-ornament consisting of few, feeble, oblique striæ, more or less irregularly arranged.

Form. & Loc. Calciferous Sandstones: Midlothian.

P. 845. Specimen wanting the caudal fin; Wardie, near Edinburgh. *Egerton Coll.*

Rhadinichthys elegantulus, Traquair.

1881. *Rhadinichthys geikiei*, R. H. Traquair (*errore*), Trans. Roy. Soc. Edinb. vol. xxx. p. 25, pl. i. figs. 13–18.
1881. *Rhadinichthys geikiei*, var. *elegantulus*, R. H. Traquair, *ibid.* p. 27, pl. ii. figs. 1–5.
1881. *Rhadinichthys delicatulus*, R. H. Traquair, *ibid.* p. 29, pl. ii. figs. 6–9. [Geological Survey of Scotland.]
1890. *Rhadinichthys elegantulus* (with var. *delicatulus*), R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 398.

Type. Fishes; Geological Survey of Scotland, Edinburgh.

A species attaining a length of about 0·1–0·15. Length of head with opercular apparatus somewhat exceeding the maximum depth of the trunk, and contained slightly more than four times in the total length; external bones ornamented with fine, vermiculating striæ, rarely passing into tubercles. Pectoral fins relatively small, their length scarcely equalling more than half that of the head; pelvic fins small and delicate; dorsal and anal fins of moderate size, similar, the former arising very slightly in advance of the latter. Flank-scales as broad as deep, ornamented with few very delicate, closely arranged striæ parallel to the anterior and inferior margins, and about four or five large oblique ridges extending across the posterior smooth area to a corresponding number of large denticulations of the hinder border; narrow ventral scales similarly marked, but with only two or three denticulations; scales of caudal region nearly smooth, with few large denticulations and short ridges.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4075–6. Four specimens, one being in counterpart.
Purchased, 1883.

P. 4075 a. Imperfect specimen, probably of this species.
Purchased, 1883.

Rhadinichthys macconochii, Traquair.

1881. *Rhadinichthys macconochii*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 30, pl. ii. figs. 12–16.

Type. Imperfect fish; Geological Survey of Scotland, Edinburgh.

A small species attaining a length of about 0·025. Length of head with opercular apparatus equal to the depth of the trunk midway between the pectoral and pelvic fins, occupying nearly one

quarter of the total length. Cranial roof-bones ornamented with close, comparatively coarse tuberculations, frequently confluent; other external bones marked with coarse striæ, much subdivided into tubercles on the mandible. Fins as in *R. elegantulus*. Scales of flank scarcely deeper than broad; none posteriorly denticulated. Scale-ornament consisting of few well-spaced striæ parallel with the anterior and inferior borders, a few faint oblique ridges also crossing the postero-superior area.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale.

P. 4077. Specimen, in counterpart. *Purchased*, 1883.

Rhadinichthys cairnsi (Jackson).

1851. *Palæoniscus cairnsii*, C. T. Jackson, Rep. Albert Coal Mine, p. 23, pl. i. fig. 3.
1852. *Palæoniscus cairnsii*, C. T. Jackson, Proc. Boston Soc. Nat. Hist. vol. iv. p. 139.
1877–78. *Palæoniscus cairnsii*, J. W. Dawson, Canadian Nat., n. s. vol. viii. p. 339, and Acadian Geology, Suppl. p. 100.

Type. Imperfect fish.

Trunk robust, with slender caudal pedicle, the maximum depth somewhat greater than the length of the head with opercular apparatus, and contained about four and a half times in the total length. Dorsal fin shorter than the anal, arising slightly in advance of the latter. Scales of flank scarcely deeper than broad; scale-ornament consisting of delicate transverse striæ, partly parallel with the inferior border, and terminating in very fine serrations of the posterior border.

Form. & Loc. Lower Carboniferous: Albert Co., New Brunswick.

P. 2274. Specimen about 0·115 in length; Hillsborough.
Egerton Coll.

Rhadinichthys alberti (Jackson).

1851. *Palæoniscus alberti*, C. T. Jackson, Rep. Albert Coal Mine, p. 22, pl. i. fig. 1.
1852. *Palæoniscus alberti*, C. T. Jackson, Proc. Boston Soc. Nat. Hist. vol. iv. p. 138.
1877. *Rhadinichthys albertii*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 559.
1877–78. *Palæoniscus alberti*, J. W. Dawson, Canadian Nat., n. s. vol. viii. p. 338, and Acadian Geology, Suppl. p. 100.

Type. Imperfect fish.

A small robust species, attaining a length of about 0·08. Maximum depth of trunk contained about four times in the total length. Head relatively small, and external bones coarsely striated. Dorsal fin arising slightly in advance of the anal, and the latter much elongated. A continuous series of enlarged ridge-scales from the dorsal fin to the occiput; flank-scales as broad as deep; scale-ornament consisting of irregular transverse striæ, more or less oblique, terminating in coarse blunt serrations of the hinder border.

Form. & Loc. Lower Carboniferous: Albert Co., New Brunswick.

P. 1010. Imperfect specimen, wanting the upper caudal lobe; Hillsborough. *Egerton Coll.*

P. 5193–4. Remains of a group of fishes, and three detached specimens displaying the squamation; Hillsborough. *Purchased*, 1885.

Rhadinichthys modulus (Dawson).

1877–78. *Palæoniscus* (*Rhadinichthys*) *modulus*, J. W. Dawson, Canadian Nat. n. s. vol. viii. p. 337, woodc. fig. 1, and Acadian Geology, Suppl. p. 100, woodc. fig. 18.

Type. Imperfect fish; Peter Redpath Museum, Montreal.

A species closely related to *R. alberti*, described as distinguished by its relatively shorter anal fin, the coarseness of the scale-ornament, and the truncation of the dorsal ridge-scales. The last-mentioned character may be a false appearance.

Form. & Loc. Lower Carboniferous; Albert Co., New Brunswick.

P. 6219. Two specimens, wanting the head; Petitcodiac River. *Presented by Sir J. William Dawson*, 1890.

Rhadinichthys tenuicauda, Traquair.

1877. *Rhadinichthys tenuicauda*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix. p. 443.

Type. Fish; Edinburgh Museum.

A small species, attaining a length of about 0·08. Body very slender and elongated, narrowly tapering posteriorly. Head-bones finely ornamented with vermiculating striæ. Fin-rays delicate, smooth, with distant articulations; dorsal and anal fins almost completely opposed, considerably in advance of the caudal fin. Scales relatively large, posteriorly serrated, nearly smooth on the

middle of the flanks and on the caudal pedicle, but dorsally and ventrally in the abdominal region marked with conspicuous oblique striæ.

Form. & Loc. Carboniferous Limestone Series: Midlothian and Lanarkshire.

49172. Imperfect fish, with fragments of the fins; Possil, near Glasgow. *Old Collection.*

P. 3438. Two similar specimens; Edge Coal Series, Wallyford. *Enniskillen Coll.*

Rhadinichthys wardi (Ward).

1875. *Palæoniscus wardi*, J. Young, Proc. Nat. Hist. Soc. Glasgow, vol. ii. pt. i. p. 66 (name only).
1875. *Palæoniscus wardi*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 239.
1877–78. *Rhadinichthys wardii*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 559, and Proc. Roy. Phys. Soc. Edinb. vol. iv. p. 239.
1890. *Rhadinichthys wardi*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 176, pl. vi. fig. 10.

Type. Imperfect fish; collection of J. Ward, Esq., Longton.

A small species, attaining a length of about 0·1. Body slender; head relatively large, the snout blunt, and the external bones finely striated. Scales of moderate size, externally ornamented with parallel oblique series of tuberculations, partially fused together, and terminating in serrations at the posterior margin.

Form. & Loc. Coal-Measures: North Staffordshire.

P. 6292. Remains of head and scales; Deep-mine Ironstone Shale, Longton. *Enniskillen Coll.*

Rhadinichthys monensis (Egerton).

1850. *Palæoniscus monensis*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. vi. p. 5, pl. i. fig. 3.
1878. *Rhadinichthys monensis*, R. H. Traquair, Proc. Roy. Phys. Soc. Edinb. vol. iv. p. 241.
1890. *Rhadinichthys monensis*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 175.

Type. Scales; British Museum.

An imperfectly known species, attaining a length of about 0·09. Head-bones coarsely striated. Scales of flank nearly equilateral; hinder border coarsely denticulated. Scale-ornament consisting

(i.) of few feeble striæ close to and parallel with the anterior and inferior borders, and (ii.) about four or five horizontal or slightly oblique ridges terminating in the posterior denticulations.

Form. & Loc. Coal-Measures: Anglesey, North Staffordshire, and Lanarkshire.

P. 608. Type scales, including the specimen figured by Egerton; Anglesey. *Egerton Coll.*

Rhadinichthys (?) angustulus, Traquair.

1881. *Rhadinichthys* (?) *angustulus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 33, pl. ii. figs. 10, 11.

Type. Imperfect fish; Geological Survey of Scotland, Edinburgh.

A doubtfully determined species of very small size, much elongated, and with a very robust caudal pedicle; head with opercular apparatus occupying about one quarter of the total length. Dorsal and anal fins similar and nearly opposite. Flank-scales somewhat deeper than broad; none posteriorly denticulated. Scale-ornament consisting of few, regular, parallel transverse striæ, straight and not bifurcating.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale.

P. 4074. Imperfect trunk. *Purchased*, 1883.

A species of doubtful genus, stated to exhibit all the pectoral rays articulated to their base, is named *Rhadinichthys* (?) *fusiformis*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 34, pl. iii. figs. 1–5. The length of the head with opercular apparatus is about equal to the maximum depth of the trunk, and contained nearly five times in the total length. Head-bones ornamented with irregularly wavy rugæ, sometimes passing into tubercles. Dorsal fin somewhat exceeding the anal in size, and arising slightly in advance of the latter. Scales well ornamented with delicate striæ, the majority of which are transverse, more or less oblique, and terminate in denticulations of the hinder border. The following specimens are preserved in the Collection :—

P. 4073. Fish wanting the greater part of the head and paired fins, the trunk measuring 0·058 from the clavicle to the base of the upper caudal lobe; Calciferous Sandstones (Cement-stone Group), Eskdale, Dumfriesshire. *Purchased*, 1883.

P. 4071. Smaller specimen, in counterpart, displaying squamation; Eskdale. *Purchased*, 1883.

P. 4072. Fragmentary specimen, displaying squamation, and exhibiting a large coprolite within; Eskdale.

Purchased, 1883.

Other species, for the most part pertaining to *Rhadinichthys*, but not represented in the Collection, are described as follows:—

Rhadinichthys ferox, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix. (1877), p. 435.—Calciferous Sandstones; Wardie, near Edinburgh. [Imperfect fish; Edinburgh Museum.]

Rhadinichthys gracilis: *Palæoniscus gracilis*, Newberry and Worthen, Pal. Illinois, vol. iv. (1870), p. 347, pl. iii. fig. 4.—Coal-Measures; Mazon Creek, Illinois.

Rhadinichthys grossarti, R. H. Traquair, Proc. Roy. Phys. Soc. Edinb. vol. iv. (1878), p. 244.—Coal-Measures; Lanarkshire. [Imperfect fishes; Grossart Collection and Geological Survey of Scotland.]

Rhadinichthys hancocki, Woodward & Sherborn, Cat. Brit. Foss. Vertebrata (1890), p. 175: *Palæoniscus hancocki*, T. Atthey, Ann. Mag. Nat. Hist. [4] vol. xv. (1875), p. 311 (reprinted in Nat. Hist. Trans. Northumb. & Durham, vol. v. 1877, p. 228).—Coal-Measures; Newsham, Northumberland. [Newcastle-upon-Tyne Museum.]

Rhadinichthys leidyanus: *Palæoniscus leidyana*, I. Lea, Journ. Acad. Nat. Sci. Philad. [2] vol. ii. (1853), p. 206, pl. xx. figs. 4, 5.—Carboniferous; Luzerne Co., Pennsylvania. [Scales.]

Rhadinichthys macrodon, R. H. Traquair, Geol. Mag. [3] vol. iii. (1886), p. 441; J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. (1890), p. 177.—Coal-Measures (Knowles Ironstone Shale); Longton, N. Staffordshire. [Imperfect fish; collection of John Ward, Esq.]

Rhadinichthys planti, R. H. Traquair, Geol. Mag. [3] vol. v. (1888), p. 253; J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. (1890), p. 177, pl. iv. fig. 6.—Coal-Measures; Lancashire and N. Staffordshire. [Imperfect fish; Salford Museum.]

Rhadinichthys tuberculatus, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. (1881), p. 31, pl. iv. figs. 1–3.—Calciferous Sandstones (Cement-stone Group); Glencartholm, Dumfries. [Imperfect fish; Geol. Surv. Scotland.]

An undefined genus and species, from the Lower Permian of Moravia, said to be allied to *Rhadinichthys*, is named *Anaglyphus insignis*, A. Rzehak, Verhandl. k.-k. geol. Reichsanst. 1881, p. 79.

Genus **PYGOPTERUS,** Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1833, p. 10, and *ibid.* pt. ii. 1844, p. 74.]

Trunk elongated, gradually tapering from the occiput. Mandibular suspensorium oblique; dentition consisting of a series of large well-spaced conical teeth, and more numerous small teeth forming an outer series; opercular apparatus relatively small; all the head and opercular bones ornamented with striations. Fins well developed, with fulcra, the rays flattened and unornamented, mostly articulated and branched. Pectoral fins having the principal rays unarticulated, except distally; pelvic fins relatively small and short-based; dorsal fin opposed to, or arising slightly in advance of the anal, high and acuminate in front, with a scarcely elongated base-line; anal fin much extended, high and acuminate in front, but low and fringe-like in its hinder half; upper caudal lobe much elongated, the fin deeply forked and nearly equilobate. Scales relatively small, thin, smooth or feebly ridged, those of the flanks of the abdominal region scarcely deeper than broad, and those of the ventral aspect not much broader than deep, except in the caudal region; the peg-and-socket articulation of the principal scales large and prominent.

Pygopterus humboldti, Agassiz.

1709. Figure by G. F. Mylius, Memorabilia Saxoniæ subterr. pt. i. fig. 1.
1719. Figures by P. Wolfart, Hist. nat. Hassiæ inf. pt. i. pls. xviii., xix.
1818. *Palæothrissum magnum,* H. D. de Blainville, Nouv. Dict. d'Hist. Nat. vol. xxvii. p. 321.
1818. *Esox eislebensis,* H. D. de Blainville, *ibid.* p. 322.
1829. "Fossil fish," A. Sedgwick, Trans. Geol. Soc. [2] vol. iii. p. 118, pl. x.
1833. *Pygopterus humboldti,* L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 10.
1833. *Pygopterus scoticus,* L. Agassiz, *ibid.* p. 10 (includes undefined species *Nemopteryx mandibularis* and *Sauropsis scoticus*).
1835. *Pygopterus humboldti,* F. A. Quenstedt, Wiegmann's Archiv, Naturg. vol. ii. p. 93.
1835. *Pygopterus scoticus,* F. A. Quenstedt, *ibid.* p. 93.
1839. *Pygopterus humboldti,* G. A. Kurtze, Comment. Petrefact. Mansfeld. p. 25.
1840. *Pygopterus humboldti,* E. F. Germar, Verstein. Mansfeld. Kupferschief. p. 22.
1842. *Pygopterus humboldti,* G. von Münster, Beitr. Petrefakt. pt. v. p. 48, pl. v. fig. 1.
1844. *Pygopterus humboldti,* L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 74, pls. liv., lv.
1844. *Pygopterus mandibularis,* L. Agassiz, *ibid.* p. 76, pls. liii., liii. *a.*

1844. *Pygopterus sculptus*, L. Agassiz, *ibid.* p. 77.
1850. *Pygopterus mandibularis*, Sir P. Egerton, in W. King's Permian Fossils (Pal. Soc.), p. 232, pl. xxiii.
1855. *Pygopterus mandibularis*, F. M'Coy, Brit. Palæoz. Foss. p. 608.
1861. *Pygopterus humboldti*, H. B. Geinitz, Dyas, p. 11, pl. xxiii. fig. 2 (*non* pl. viii. figs. 1–3).
1861. *Pygopterus mandibularis*, H. B. Geinitz, *ibid.* p. 12.
1877. *Pygopterus humboldtii*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 574.
1877. *Pygopterus mandibularis*, R. H. Traquair, *ibid.* p. 575.

Type. Imperfect fish.

The type species, attaining a length of about 0·6. Maximum depth of trunk contained about six times in the total length. Head and opercular apparatus occupying little more than one-fifth of the total length; large teeth much elongated, slender, the enamelled crown fixed upon a very broad, prominent base, with few vertical folds; ornamentation of cranial, facial, and opercular bones very fine. Pelvic fins about half as large as the pectorals, arising half-way between the latter and the anal; dorsal fin about half as long as the anal, equally elevated, and arising slightly in advance of the latter; length of anal fin about one-sixth of the total length of the fish. Scales of flank having the antero-superior angle produced upwards; all scales smooth, except towards the dorsal margin, where they are crossed by few, large, transverse ridges, more or less parallel and often oblique.

Form. & Loc. Upper Permian (Kupferschiefer): Germany. Upper Permian (Marl Slate): Durham and Northumberland.

(i.) *Kupferschiefer.*

38589. Imperfect remains of an individual of moderate size, much crushed and chemically disintegrated, but displaying the relative proportions of the head and tail; Riechelsdorf, Hesse. *Purchased*, 1864.

P. 833. Imperfect individual wanting the caudal fin, but displaying the pectorals and the greater portion of the dorsal and anal fins; Eisleben, Saxony. The non-articulated character of the pectoral fin-rays is well shown, and a few displaced dorsal scales exhibit the ridged ornament. *Egerton Coll.*

P. 3414. Remains of small individual, coiled up, and wanting the greater portion of the abdominal region; Mansfeld, Thuringia. Traces of the striated ornament of the head-

bones are observed, and the smoothness of the operculum and suboperculum is doubtless due to superficial corrosion. *Enniskillen Coll.*

18505. Portions of head and trunk showing pectoral and pelvic fins; Thuringia. *Purchased*, 1844.

28427–28. Two imperfect specimens of the head and opercular apparatus; Eisleben. *Mantell Coll.*

P. 834. Portion of jaws and pectoral arch; Riechelsdorf. *Egerton Coll.*

P. 3414 a. Portion of coiled-up trunk, with pectoral, pelvic, and dorsal fins; Mansfeld. *Enniskillen Coll.*

P. 3414 b. Middle portion of trunk with fragments of pelvic, dorsal, and anal fins; Riechelsdorf. *Enniskillen Coll.*

14371. Imperfect caudal region, wanting the greater portion of the anal and caudal fins; Eisleben. The proportions of the neural arches beneath the dorsal fin are distinct. *Purchased*, 1841.

18509. Small fish, 0·16 in length from the hinder border of the pectoral arch to the base of the caudal fin, probably young of this species; Eisleben. There are well-preserved remains of all the fins except the caudal, though the posterior extension of the anal is broken away; and some of the neural and hæmal arches of the vertebral axis are distinctly seen under the thin squamation. *Purchased*, 1844.

(ii.) *Marl Slate.*

P. 3416. Nearly complete fish, 0·6 in length, with much crushed head; Midderidge. In the abdominal region the neural spines are distinctly shown, not less than thirty in number; and in the anterior half of the caudal region both neural and hæmal arches are preserved. The fins and squamation are also indicated, but too imperfect for detailed description. *Enniskillen Coll.*

P. 3416 a. Slightly smaller individual, the head and abdominal region being very imperfect, but the caudal region almost complete; Midderidge. Some of the cranial roof-bones and the maxilla exhibit the characteristic irregular striations, and there are traces of the large laniary teeth.

Well-developed fulcra are observed on a fragment of the pelvic fins, as also on the anterior border of each of the median fins; and in the latter the foremost nine or ten rays gradually increase in length, until the longest ray is reached. The dorsal fin is almost the precise counterpart of the anterior half of the anal; and while the longest ray of the latter measures about 0·065 in length, the depth of its hinder fringe-like portion scarcely exceeds 0·012. In both these fins the articulations of the rays are distant, the joints being much longer than broad, and the basal joint at least twice as long as any of the others. The upper caudal lobe measures not less than 0·17 in length, while the lower lobe of the fin cannot have exceeded a length of 0·12 or 0·13. The rays of the anterior half of the lower lobe of this fin are more robust and more closely articulated than those of the upper lobe and of the other median fins. In the squamation all the characters of the genus and species are displayed, and the posterior half of each dorsal scale continues to exhibit the ridged ornament even to the end of the caudal region; immediately beneath the dorsal fin, however, all the scales are destitute of ornamentation, possibly abraded. Portions of the lateral line are distinct. *Enniskillen Coll.*

39698. Imperfect remains of head, pectoral fin, and anterior abdominal region in counterpart; Midderidge.
Purchased, 1866.

43267. Portions of head and anterior abdominal region; Midderidge. *Purchased*, 1871.

P. 3408. Imperfect remains of head and anterior abdominal region, with some pectoral fin-rays; Midderidge.
Enniskillen Coll.

P. 3415. Imperfect remains of head and trunk, wanting all the fins, except a few rays of the pectoral and pelvic pairs; Ferry Hill. The striations of the head-bones are shown in impression, and the large teeth exhibit the characters noted in the specific diagnosis. Portions of nearly all the neural arches in the abdominal region are preserved, and there is a distinct paired series of short, broad, hæmal elements. The ridged ornamentation of the dorsal scales is shown by impressions to have been comparatively prominent. *Enniskillen Coll.*

P. 3408 a. Portions of skull and mandible; Midderidge.
Enniskillen Coll.

P. 838. Imperfect jaws, in counterpart; Clarence Railway, Durham.
Egerton Coll.

36057. Imperfect caudal region with portions of fins; Midderidge. Several of the features noted in no. P. 3416 *a* are also shown in this specimen, but the dorsal scales beneath the dorsal fin are as distinctly ornamented as those beyond.
Purchased, 1861.

28613. Middle portion of caudal region with dorsal and anal fins; Ferry Hill. The head and anterior abdominal region of a *Palæoniscus* are associated in such a manner as to suggest its having been swallowed by the fish.
Purchased, 1853.

P. 838 a. Fragment of trunk; Whitley, Northumberland.
Egerton Coll.

The specimen mentioned below is described and figured as the type of a distinct species, *Pygopterus latus*, Egerton, in W. King, Permian Fossils (Palæont. Soc. 1850), p. 233, pl. xxiv. No other example is known, and it seems probable that the proportions different from those of the type species are due merely to accidental crushing. It is labelled *Pygopterus mandibularis*, in Agassiz's handwriting.

P. 552. Imperfect head and trunk, about 0·48 in length, much crushed and wanting all the fins; Marl Slate, Ferry Hill, Durham. That the unusual depth of the trunk is due at least to a considerable extent to crushing and distortion, is proved by the great width of the space between the neural and hæmal arches in the caudal region, as also between the neural arches and the supporting bones of the dorsal fin. These bones are more numerous than indicated in Mr. Dinkel's drawing, there being not less than sixteen readily distinguishable elements in the series, and they are scarcely so stout as represented. It is impossible to count the scales with certainty, and the slight obliquity of some of the vertical series in the abdominal region may be explained by distortion. *Egerton Coll.*

A doubtful fossil from the Coal-Measures of Linton, Ohio, is named *Pygopterus scutellatus*, J. S. Newberry, Proc. Acad. Nat. Sci.

Philad. vol. viii. (1856), p. 98. The specimen is regarded as Amphibian by E. D. Cope, *ibid.* 1873, p. 418.

Pygopterus lucius, L. Agassiz, Poiss. Foss. vol. ii. pt. i. (1833), p. 10, is an undefined name applied to a head of *Archegosaurus*, from the Lower Permian of Saarbrück, in the Stuttgart Museum. *Pygopterus bonnardi*, L. Agassiz (*ibid.* p. 11), and *P. jamesoni*, L. Agassiz (*ibid.* pt. ii. 1844, p. 78), are also undefined names referring respectively to unknown fossils from the Lower Permian of Autun, France, and the Calciferous Sandstone of Burdiehouse, near Edinburgh. The latter may be a synonym of *Elonichthys bucklandi* (R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 577).

Genus **TRACHELACANTHUS**, Fischer de Waldheim.

[Kurze Beschreibung eines fossilen Fisches, *Trachelacanthus*, 1850.]

Trunk elongated. Mandibular suspensorium oblique; jaws robust, provided with large, conical, laniary teeth. Fins relatively small, with bifurcating rays and long, slender fulcra; dorsal fin remote, arising somewhat in advance of the anal. Scales small, deepest on the flank, smooth or feebly ornamented with large oblique ridges; ridge-scales small, but prominent.

The so-called spine beneath the jaws, to which the generic name refers, is a false appearance (probably a displaced branchiostegal ray) in the type specimen; but the genus is distinguished from *Palæoniscus*, with which it is sometimes identified, by the dentition.

The type and only known species is as follows:—

Trachelacanthus stschurovskii, G. Fischer de Waldheim, *op. cit.* (Moscow, 1850), pp. 9–11, with plate: *Palæoniscus stschurowskii*, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1587.—Permian; Govt. of Wologda, Russia. [Fish, wanting paired fins; University of Moscow.]

Genus **UROLEPIS**, Bellotti.

[In A. Stoppani, Studii Geol. e Paleont. Lombardia, 1857, p. 431.]

An imperfectly defined genus of small Palæoniscidæ. Mandibular suspensorium oblique; dentition with powerful laniaries. Fins large, with fulcra, the dorsal opposed to the anal, and the latter somewhat extended. Scales ornamented with few oblique ridges.

The type species is *Urolepis macroptera*, C. Bellotti, *op. cit.* p. 432, from the Upper Trias of Lombardy. The same horizon also yields

U. elongata, Bellotti (*ibid.* p. 425), and *U. microlepidota*, Bellotti (*ibid.* p. 433). Of *U. elongata*, the type specimen is in the Milan Museum; of the other species, the types are in the Stoppani Collection.

Genus **PHANEROSTEON**, Traquair.

[Trans. Roy. Soc. Edinb. vol. xxx. 1881, p. 39.]

Trunk fusiform, elongated. Mandibular suspensorium oblique; [dentition unknown]. Fin-rays delicate, articulated, and distally bifurcating; fulcra absent. Dorsal fin elevated, not acuminate, opposed in great part to the space between the pelvic fins and the anal; caudal fin somewhat forked, inequilobate. Trunk naked, or with rudiments of rhomboidal scales anteriorly; upper caudal lobe invested with elongated rhomboidal scales.

Phanerosteon mirabile, Traquair.

1881. *Phanerosteon mirabile*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 39, pl. iii. figs. 6–8.

Type. Imperfectly preserved fish; Geological Survey of Scotland.

The type species, attaining a length of about 0·08. Head and opercular apparatus occupying about one quarter of the total length; cranial roof-bones tuberculated; expansion of maxilla exhibiting striæ parallel with the hinder and superior margins, and its dentary border finely tuberculated; mandible obliquely striated. Few remnants of scales immediately behind the clavicle.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4703. Imperfectly preserved individual. *Purchased*, 1884.

P. 5984. Fish wanting the greater part of the fins. *Purchased*, 1889.

P. 5984 a. Imperfect caudal region, and portions of the paired fins. *Purchased*, 1889.

Genus **PALÆONISCUS**, Blainville.

[Nouv. Dict. d'Hist. Nat. vol. xxvii. 1818, p. 320 (*Palæoniscum*).]

Syn. *Palæothrissum*, H. D. de Blainville, *ibid.* p. 320.
Eupalæoniscus, A. Rzehak, Verhandl. k.-k. geol. Reichsanst. 1881, p. 79.

Trunk elongated. Mandibular suspensorium very oblique; mandible slender: teeth small, conical, and acutely pointed, of different sizes, the smaller ones being more externally placed, but without specially prominent laniaries. Fins relatively small, with minute fulcra, and the rays distally bifurcating, more or less coated with ganoine; pectoral rays all articulated; the dorsal opposed to the space between the pelvic and anal fins. Scales partially sculptured with irregular transverse furrows and dots, and the hinder free margin usually serrated.

The generic definition here adopted is more restricted than that of Blainville and Agassiz[1], being in accordance with the most recent researches of Traquair[2].

Palæoniscus freieslebeni, Blainville.

1708. *Ichthyolithus eislebensis*, J. J. Scheuchzer, Piscium Querelæ et Vindiciæ, pl. ii. fig. 1, pl. iv. fig. 2.
1708. Figures by C. N. Lange, Historia Lapidum figuratorum Helvetiæ, &c., pl. vi. fig. 3, pl. vii. fig. 4.
1709. Figures by G. F. Mylius, Memorabilia Saxoniæ subterraneæ, pt. i. figs. ii., iii., v.
1710. Figures by M. D. S. Buttner, Rudera diluvii testes, pl. xviii. figs. 3, 4.
1719. Figures by P. Wolfart, Historia naturalis Hassiæ inferioris, pt. i. pl. xii. fig. 1, pl. xiv. figs. 2–4, pls. xvi., xvii., xx.
1730. Figure by Leibknecht, Hassiæ subterraneæ specimen, pl. v. fig. 1.
1768. Figures by Knorr & Walch, Naturgeschichte Verstein. pl. xvii. figs. 1, 2, pl. xviii. fig. 2, pl. xix. figs. 1, 2, pl. xx. figs. 2, 3.
1818. *Palæoniscum freieslebenense*, H. D. de Blainville, Nouv. Dict. d'Hist. Nat. vol. xxvii. p. 320.
1818. *Palæothrissum macrocephalum*, H. D. de Blainville, *ibid.* p. 320.
1818. *Clupea lametherii*, H. D. de Blainville, *ibid.* p. 321.
1824. *Acipenser bituminosus*, E. F. Germar, Leonhard's Mineral. Taschenbuch, p. 67.
1829. *Palæothrissum blennioides*, F. Holl, Petrefaktenkunde, p. 131.
1829. *Palæothrissum magnum*, A. Sedgwick, Trans. Geol. Soc. [2] vol. iii. p. 117, pl. viii. figs. 1, 2.
1829. *Palæothrissum macrocephalum*, A. Sedgwick, *ibid.* p. 117, pl. ix. fig. 2.
1829. *Palæothrissum elegans*, A. Sedgwick, *ibid.* p. 117, pl. ix. fig. 1.
1833. *Palæoniscus freieslebeni*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 5, 66, pls. xi., xii.
1833. *Palæoniscus elegans*, L. Agassiz, *ibid.* pp. 5, 95, pl. x. *b.* figs. 4, 5.

[1] Poiss. Foss. vol. ii. pt. i. (1833), p. 41.
[2] Quart. Journ. Geol. Soc. vol. xxxiii. (1877), p. 557.

1835. *Palæoniscus comtus*, L. Agassiz, *ibid.* p. 97, pl. x. *b*. figs. 1–3.
1835. *Palæoniscus freieslebeni*, F. A. Quenstedt, Wiegmann's Archiv Naturg. vol. ii. p. 94.
1839. *Palæoniscus freieslebeni*, G. A. Kurtze, Comment. Petrefact. Mansfeld. p. 12.
1840. *Palæoniscus freieslebeni*, E. F. Germar, Verstein. Mansfeld. Kupferschief. p. 12, figs. 9–14.
1849. *Palæoniscus comptus*, W. C. Williamson, Phil. Trans. p. 445, pl. xl. fig. 7.
1850. *Palæoniscus comtus*, Sir P. Egerton, in King's Permian Foss. (Palæont. Soc.), p. 223, pl. xxi. fig. 1.
1850. *Palæoniscus elegans*, Sir P. Egerton, *ibid.* p. 223, pl. xxii. fig. 1.
1855. *Palæoniscus freieslebeni*, F. M'Coy, Brit. Palæoz. Foss. p. 606.
1855. *Palæoniscus elegans*, F. M'Coy, *ibid.* p. 605.
1861. *Palæoniscus freieslebeni*, H. B. Geinitz, Dyas, p. 15, pl. vi. figs. 4–7, pl. vii. fig. 1.
1861. *Palæoniscus elegans*, H. B. Geinitz, *ibid.* p. 16, pl. vii. fig. 2.
1877. *Palæoniscus comptus*, R. H. Traquair, Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), pl. i. figs. 4, 6.
1877. *Palæoniscus freieslebeni*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 557.
1887. *Palæoniscus freieslebeni*, K. A. von Zittel, Handb. Palæont. vol. iii. p. 190, woodc. figs. 198, 201, 202.
1889. *Palæoniscus frieslebeni*, R. Howse, Guide Coll. Local Foss. Mus. Nat. Hist. Soc. Newcastle-upon-Tyne, pp. 21, 24.

Type. Nearly complete fishes; Paris Museum of Natural His[illegible]tory.

The type species, attaining a maximum length of [illegible]ut 0·3. Trunk regularly fusiform and the caudal pedicle robust[illegible]reatest depth contained about five and a half times in the tot[illegible]ength. Head and opercular apparatus occupying nearly one-fi[illegible] total length; cranial bones marked with coarse, closely arranged vermiculating rugæ and elongated tubercles of ganoine. Fin-rays broad, covered with ganoine, and ornamented as the scales. Pelvic fins situated much nearer to the anal than to the pectoral pair, arising immediately in advance of the origin of the dorsal. Dorsal fin at least as high as long, larger than the anal. Scales of moderate size, marked in front with a few irregular, short, transverse grooves, in the hinder half with sparse elongated pittings, and the hinder margin denticulated except in those towards the extremity of the caudal pedicle.

Form. & Loc. Upper Permian (Kupferschiefer): Thuringia, Saxony, and Hesse. Upper Permian (Marl Slate and Lower Magnesian Limestone): Durham and Northumberland.

(i.) *Kupferschiefer.*

857–8. Two typical specimens of moderate size; Kupferschiefer, Mansfeld, Thuringia. *Purchased.*

P. 6298. Imperfect small specimen; German Kupferschiefer. *Presented by His Majesty King George* IV., 1823.

33217. Imperfect small specimen; Mansfeld. *Purchased*, 1854.

P. 1020. Two specimens; Mansfeld. *Egerton Coll.*

P. 6293. Young individual, about 0·13 in length; Mansfeld. *Enniskillen Coll.*

8049. Small individual; Kupferschiefer, Eisleben, Saxony.

19810 c. Two small specimens; Eisleben. *Purchased*, 1845.

19945. Two vertically-crushed fishes; Eisleben. *Purchased*, 1846.

P. 4347. Two typical specimens; (?) Eisleben. *Enniskillen Coll.*

20669–70, 20672. Three imperfect specimens; Kupferschiefer, Riechelsdorf, Hesse. *Purchased*, 1846.

28426. Three much crushed and contorted individuals, and a more satisfactorily preserved specimen in counterpart; Riechelsdorf. *Mantell Coll.*

P. 6294. Four typical specimens; Riechelsdorf.

39251. Well-preserved fish, 0·29 in length, displaying the fins; Riechelsdorf. *Purchased*, 1865.

P. 1[illegible]8. Remains of two small individuals; Riechelsdorf. *Egerton Coll.*

P. 4348, P. 4348 a. Two small specimens, one displaying the squamation; also an imperfect very young individual, labelled by Agassiz; Riechelsdorf. *Enniskillen Coll.*

P. 6070. Large individual wanting the extremity of the tail; German Kupferschiefer. *Presented by F. Harford, Esq.*, 1889.

P. 6295. Six fragmentary specimens; German Kupferschiefer.

(ii.) *Marl Slate.*

28613 a. Impression of a small fish imperfect in the anterior part of the dorsal region, and four other individuals variously crushed and broken; Marl Slate, Ferry Hill, Durham. *Purchased*, 1853.

25963. Fragment of trunk labelled *Palæoniscus elegans* by Agassiz; Ferry Hill. *Dixon Coll.*

P. 1025, P. 1028. Five specimens, three being labelled *Palæoniscus elegans* by Agassiz; Ferry Hill. The largest example is very imperfect, but measures not less than 0·3 in total length; and three of the others exhibit various bones of the head and opercular apparatus. *Egerton Coll.*

P. 352–3. Two small individuals, one in counterpart; Ferry Hill. *Purchased*, 1881.

P. 3425. Three imperfect fishes and the hinder portion of a large trunk, the latter and two of the former labelled *Palæoniscus comtus* by Agassiz; Ferry Hill. *Enniskillen Coll.*

P. 3426, P. 4350. Similar fish, crushed and imperfect dorsally, and two smaller individuals; Ferry Hill. *Enniskillen Coll.*

28613 b. Crushed portions of head and abdominal region; Marl Slate, Darlington. *Purchased*, 1853.

36038–39. Two imperfect typical specimens; Darlington. *Purchased*, 1861.

36036–37, 36040. Head and anterior portion of trunk, a vertically crushed fish, and part of a small trunk; Marl Slate, Midderidge, Durham. *Purchased*, 1861.

40647. Fine large specimen, somewhat fractured; Midderidge. *Purchased*, 1867.

P. 6296. Portion of head and anterior abdominal region; Midderidge. *Enniskillen Coll.*

P. 1024. Imperfect trunk; Marl Slate, East Thickley, Durham. *Egerton Coll.*

P. 4351. Portions of head and abdominal region; East Thickley. *Enniskillen Coll.*

11290. Portions of small trunk; Marl Slate, Whitley, Northumberland. *Mantell Coll.*

P. 6297. Much crushed trunk; Whitley.

Palæoniscus magnus, Agassiz.

1708. Figures by J. J. Scheuchzer, Piscium Querelæ et Vindiciæ, pl. iv. figs. 1, 3.

1719. Figure by P. Wolfart, Hist. nat. Hassiæ inf. pt. i. pl. xv.

1834. *Palæoniscus magnus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 78, pls. xiii., xiv.
1839. *Palæoniscus magnus*, G. A. Kurtze, Comment. Petrefact. Mansfeld. p. 13.
1839. *Palæoniscus megacephalus*, G. A. Kurtze, *ibid.* p. 17.
1840. *Palæoniscus magnus*, E. F. Germar, Verstein. Mansfeld. Kupferschief. p. 18.
1850. *Palæoniscus megacephalus* = *P. freieslebeni*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. vi. p. 6.
1861. *Palæoniscus magnus*, H. B. Geinitz, Dyas, p. 16.

Type. Nearly complete fishes; Paris Museum of Natural History.

A very large species, attaining a maximum length of about 0·4. Trunk regularly fusiform and the back somewhat arched in advance of the dorsal fin; greatest depth contained about four and a half times in the total length. Head and opercular apparatus occupying more than one-fifth of the total length; cranial bones marked with coarse, closely arranged, vermiculating rugæ and elongated tubercles of ganoine. Fin-rays broad, covered with ganoine, and ornamented as the scales; proportions and arrangement of fins as in *P. freieslebeni*. Scales relatively larger than in the last-named species, with fewer grooves and pittings.

Form. & Loc. Upper Permian (Kupferschiefer): Thuringia, Hesse, and Hanover.

P. 3474. Young individual, 0·195 in length; Riechelsdorf, Hesse. *Enniskillen Coll.*

28425. Portion of trunk; Riechelsdorf. *Mantell Coll.*

P. 1015. Typical specimen, wanting the greater part of the head and the extremity of the tail, labelled by Agassiz; Riechelsdorf. *Egerton Coll.*

P. 3423–24. Imperfect trunk, and a much crushed and distorted fish in counterpart; Riechelsdorf. *Enniskillen Coll.*

15405. Imperfect trunk, with portions of fins; Mansfeld, Thuringia. *Purchased*, 1840.

18506. Imperfect head and greater portion of trunk; Mansfeld. *Purchased*, 1844.

P. 1014. Two fishes wanting the extremity of the tail, and three more imperfect specimens; Eisleben (Saxony) and Mansfeld. *Egerton Coll.*

P. 3423 a. Two specimens showing the head and parts of the trunk; Eisleben, Saxony. *Enniskillen Coll.*

43430. A much elongated large trunk, perhaps owing its form to accidental crushing, and, if so, referable to *P. magnus*; Riechelsdorf.

Presented by Kenneth Murchison, Esq., 1872.

Palæoniscus macropomus, Agassiz.

1833. *Palæoniscus macropomus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 5, 81, 103, pl. ix. figs. 6, 7.

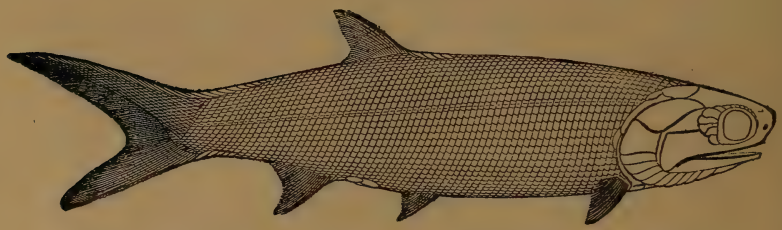
1877. *Palæoniscus macropomus*, R. H. Traquair, Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), pl. i. figs. 1–3.

Type. Small fish wanting extremity of tail.

A species closely related to *P. freieslebeni*, but distinguished, according to the original diagnosis, by the less tapering form of the caudal region, the relatively larger size of the head, the greater breadth of the opercular apparatus, and the comparative straightness and elongation of the branchiostegal rays. The scales of the flank are also said to be less vertically elongated than those of the type species —a somewhat doubtful distinction.

Form. & Loc. Upper Permian: Thuringia.

Fig. 55.



Palæoniscus macropomus, Agassiz.—Restoration by R. H. Traquair.

All the following specimens are preserved in nodules from the Kupferschiefer of Ilmenau, near Henneberg, and those forming part of the Egerton and Enniskillen collections are assigned to this species by Agassiz, *tom. cit.* p. 103:—

P. 1029, P. 3427. Five imperfect individuals about 0·2–0·23 in length, two being in counterpart.

Egerton & Enniskillen Colls.

P. 3427 a, P. 4349. Small trunk, and part of the squamation of a large individual labelled by Agassiz. *Enniskillen Coll.*

1341 (Sloane Cat.). Crushed remains of a coiled-up individual, in counterpart. *Sloane Coll.*

1337–39 (Sloane Cat.). Three fragmentary specimens, in counterpart. *Sloane Coll.*

Palæoniscus longissimus, Agassiz.

1835. *Palæoniscus longissimus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 100, pl. x. *c.* fig. 4.

1850. *Palæoniscus longissimus*, W. King, Permian Foss. (Palæont. Soc.), p. 225, pl. xxi. fig. 2.

Type. Imperfect fish, wanting the greater part of the head; British Museum (in part).

Trunk narrow and elongated, the greatest depth contained about six and a half times in the total length, which rarely exceeds 0·2. Head and opercular apparatus occupying somewhat less than one-fourth of the total length; cranial bones marked with coarse rugæ and elongated tubercles of ganoine, apparently more sparsely arranged than in *P. freieslebeni*. Fin-rays broad. Pelvic fins situated much nearer to the anal than to the pectoral pair, arising immediately in advance of the origin of the dorsal; dorsal fin somewhat longer than high, twice as large as the anal. Scales of moderate size, with a prominent ornamentation of short transverse grooves and elongated pittings.

Form. & Loc. Upper Permian: Durham and Northumberland.

P. 1023. Counterpart of type specimen; Marl Slate, Clarence Railway cutting, near Mainsforth, Durham. *Egerton Coll.*

28613 c. Small imperfectly preserved trunk; Marl Slate, Midderidge, Durham. *Purchased*, 1853.

43268–69. Two typical specimens; Midderidge. *Purchased*, 1871.

P. 3473. Vertically crushed head and trunk, wanting the extremity of the tail; Midderidge. *Enniskillen Coll.*

P. 1022. Impression of nearly complete fish, displaying the fins; Marl Slate, Whitley, Northumberland. *Egerton Coll.*

Palæoniscus macrophthalmus, Agassiz.

1835. *Palæoniscus macrophthalmus*, L. Agassiz, Poiss. Foss, vol. ii. pt. i. p. 99, pl. x. *c.* fig. 3.

1850. *Palæoniscus macrophthalmus*, Sir P. Egerton, in King's Permian Foss. (Palæont. Soc.), p. 225, pl. xxii. fig. 2.

1855. *Palæoniscus macrophthalmus*, F. M'Coy, Brit. Palæoz. Foss. p. 607.

1861. *Palæoniscus macrophthalmus*, H. B. Geinitz, Dyas, p. 17, pl. vii. fig. 3.

Type. Nearly complete fish; Geological Society of London.

A small species, attaining a maximum length of about 0·12; or possibly a young stage merely of *P. freieslebeni*. Trunk robust, the greatest depth contained about six times in the total length; head and opercular apparatus large, occupying somewhat less than one fourth of the total length; orbit relatively large. Fins as in *P. freieslebeni*. Scales small and feebly ornamented.

Form. & Loc. Upper Permian (Marl Slate): Northumberland and Durham. Upper Permian (Kupferschiefer): Hesse.

28613 d. Two large specimens, one showing the fins, the other coiled up; Marl Slate, Durham. *Purchased*, 1853.

35736–37. Two small specimens, one wanting the head; Marl Slate, Ferry Hill, Durham. *Purchased*, 1860.

P. 1025. A large fish, chiefly in impression, labelled as a young individual of *P. comtus* by Agassiz; Ferry Hill. *Egerton Coll.*

P. 3484. Imperfect remains of large individual; Marl Slate, Midderidge, Durham. *Enniskillen Coll.*

P. 354. Crushed specimen with relatively larger scales; Marl Slate, probably from Cullercoats, Northumberland. *Purchased*, 1881.

P. 5139. Small individual, apparently elongated by pressure; Cullercoats. *Presented by William Dinning, Esq.*, 1886.

Small forms of *Palæoniscus* from the German Kupferschiefer, apparently indeterminable immature individuals, are named *Palæoniscus pygmæus* (H. von Meyer, Neues Jahrb. 1848, p. 467, name only). The following specimens are of this character:—

P. 3476–7. Remains of head and trunk, about 0·055 in length, and an imperfect trunk; Riechelsdorf, Hesse. These specimens were doubtless intended to be the types of *P. pygmæus*. *Enniskillen Coll.*

P. 1016. Caudal region of equally small fish; Riechelsdorf. *Egerton Coll.*

The following species have also been determined, but there are no examples in the Collection :—

(?) *Palæoniscus delessei*, H. E. Sauvage, Bull. Soc. Géol. France, [3] vol. vi. (1878), p. 626, pl. xii.—Upper Coal-Measures ; Buxière-les-Mines, Allier. [Imperfect fish with portions of the fins.]

(?) *Palæoniscus kablikæ*, H. B. Geinitz, Dyas (1861), p. 20, pl. x. fig. 1.—Lower Permian ; Hohenelbe. [The type specimen of this fish, in the Dresden Museum, is much crushed and distorted, and the large size of the fin suggests an error in the generic determination.]

Palæoniscus tscheff'kini, G. Fischer de Waldheim, Bull. Soc. Imp. Nat. Moscou, 1842, p. 464, pl. iv. (*tschevkinii*) ; E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1582, pl. lv. fig. 13.—Permian ; Kargala, Govt. of Orenburg, Russia. [Imperfect caudal region.]

Detached scales and other fragments of undetermined genera have also been named as follows :—

Palæoniscus antiquus, H. U. Williams, Bull. Buffalo Soc. Nat. Sci. vol. v. (1886), p. 84, fig. 2.—Portage Group ; Sturgeon Point, Erie Co., N.Y.

Palæoniscus baini, Sir P. Egerton, Trans. Geol. Soc. [2] vol. vii. (1856), p. 227, pl. xxviii. figs. 26, 27, 31, 33, 34, 37, 38. —Karoo Beds ; Styl Krantz, Cape Colony.

Palæoniscus devonicus, J. M. Clarke, Bull. U. S. Geol. Surv. vol. iii. (1885), pp. 20, 41, pl. i. figs. 2–6.—Genesee Shales ; New York State.

Palæoniscus reticulatus, H. U. Williams, *tom. cit.* (1886), p. 83, fig. 1.—Portage Group ; Sturgeon Point, Erie Co., N.Y.

Palæoniscus sculptus, Sir P. Egerton, Trans. Geol. Soc. [2] vol. vii. (1856), p. 227, pl. xxviii. figs. 28–30, 32, 35, 36, 39, 40.— Karoo Beds ; Styl Krantz, Cape Colony.

The following species, from the Lower Permian of Bohemia, have also been named, but without description :—

Palæoniscus deletus, A. Fritsch, Sitzungsb. k. böhm. Gesell. Wiss. 1877, p. 46. [Scales ; Royal Bohemian Museum.]

Palæoniscus ? sculptus, A. Fritsch, *ibid.*, 1879, p. 190. [Small imperfect fish ; Royal Bohemian Museum.]

The species mentioned below, and originally assigned to *Palæo-*

niscus, will be considered in Part III. of this Catalogue under the generic names indicated:—

Palæoniscus catopterus, Ag., and *superstes*, Egert., assigned to *Dictyopyge*.

Palæoniscus glaphyrus, Ag., *abbsi*, Kirkby, *altus* (*latus*), Kirkby, and *varians*, Kirkby, assigned to *Acentrophorus*.

Palæoniscus arenaceus, Berger, *fultus*, Ag., *ovatus*, Redfield, *agassizi*, Redfield, *macropterus*, Redfield, and *latus*, Redfield, assigned to *Semionotus*.

Palæoniscus maacki, Rohon, and *sibiricus*, Rohon, assigned to *Colobodus*.

Genus **APATEOLEPIS**, A. S. Woodward.

[Mem. Geol. Surv. N. S. Wales, Palæont. no. 4, 1890, p. 12.]

Trunk slender, fusiform. Head of moderate size, snout prominent, and suspensorium very oblique; teeth minute. Fins well developed, without fulcra, the rays delicate, closely arranged, articulated, and bifurcating distally. Dorsal and anal fins high and triangular, the former situated in advance of the latter; upper caudal lobe much produced, the fin being deeply forked and nearly equilobate. Scales of the trunk rhomboidal and extremely delicate, marked with diagonal striæ.

Apateolepis australis, A. S. Woodward.

1890. *Apateolepis australis*, A. S. Woodward, *op. cit.*, p. 13, pl. iv. figs. 1–4.

Type. Imperfect fish; Museum of Geol. Survey, N. S. Wales, Sydney.

The type species, attaining a length of about 0·2. Maximum depth of trunk contained about six times, and the length of the head with opercular apparatus somewhat more than four times in the total length. Pelvic fins relatively large; dorsal fin much larger than the anal, and completely in advance of the latter. External bones finely striated; scales with two or three coarse striæ.

Form. & Loc. Hawkesbury Beds (Upper Trias): New South Wales.

P. 6268. Two fragments. *By exchange*, 1890.

A genus closely related to *Apateolepis*, as yet very imperfectly defined, is named *Actinophorus*, J. S. Newberry, Trans. New York

Acad. Sci. vol. vii. (1888), p. 179. The type species is very large and described thus :—

Actinophorus clarki, J. S. Newberry, *ibid.* p. 179, and Palæoz. Fishes N. America (Mon. U. S. Geol. Surv. no. xvi. 1889), p. 175, pl. xlix. fig. 1.—Cleveland Shale (Lower Carboniferous); Cuyahoga Co., Ohio. [Anterior portion of fish; Columbia College, New York.]

Genus **ELONICHTHYS**, Giebel.

[Fauna der Vorwelt, Fische, 1848, p. 249.]

Syn. (?) *Propalæoniscus*, A. Pomel, Catal. Méthod. Vert. Foss. 1853 p. 133.
Rhabdolepis, F. H. Troschel, Verhandl. naturh. Verein. preuss. Rheinl. u. Westphal. 1857, p. 15.
(?) *Ganacrodus*, R. Owen, Trans. Odontol. Soc. vol. v. 1867, p. 349.
Cosmoptychius, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. 1877, p. 553.

Trunk more or less deeply fusiform. Mandibular suspensorium very oblique; jaws stout and teeth acutely conical, arranged in two series—an inner row of well-spaced laniaries and an outer row of numerous, closely arranged small teeth; bones of head and opercular apparatus ornamented with tuberculations and striæ. Fins large, with fulcra, the rays branching distally, covered with ganoine, and the more robust sculptured. Pectoral, pelvic, dorsal, and anal fins triangular, acuminate; pectoral fin-rays articulated; pelvic fins with short base-line; dorsal opposed to space between the pelvic and anal fins; upper caudal lobe much produced, the fin deeply forked and inequilobate. Scales of moderate thickness, very slightly imbricating, covered with ganoine more or less sculptured; ridge-scales immediately in advance of median fins much enlarged.

In the amended definition of this genus by Traquair (Ganoid Fishes Brit. Carb. Form. 1877, p. 47), the true interoperculum ("suboperculum") is stated to be absent. This element, however, has subsequently been discovered as a small triangular bone (Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 397).

Elonichthys germari, Giebel.

1848. *Elonichthys germari*, C. G. Giebel, Fauna der Vorwelt, Fische, p. 250.

1848. *Elonichthys germari*, C. G. Giebel, Gaea Excurs. German. p. 161, pl. vi. fig. 58.

1849. *Elonichthys germari*, E. F. Germar, Verstein. Steinkohlengeb. Wettin, p. 74, pl. xxx. figs. 1–4.

Type. Imperfect fish; Halle University Museum.

The type species of moderate size. Head with opercular apparatus occupying about one quarter of the total length; external bones coarsely and irregularly marked with striations, often subdivided into elongated tubercles. Fin-rays very robust, obliquely striated. Scales relatively large, and those of the flank scarcely deeper than broad; none posteriorly serrated. Scale-ornament consisting of branched and intercalated striæ, very prominent in the abdominal region, but feeble towards the extremity of the tail; the striæ of each scale directed for the most part antero-posteriorly and divided into two unconformable areas by the diagonal extending from the antero-superior to the postero-inferior angle.

Form. & Loc. Coal-Measures: Province of Saxony.

P. 4395. Portions of head-bones and fin-rays, with numerous scattered scales; Wettin, near Halle. *Enniskillen Coll.*

Closely related to this species, but somewhat smaller, is the fish named *Elonichthys caudalis*, R. H. Traquair, Ganoid Fishes Brit. Carb. Form. (Pal. Soc. 1877), p. 53, pl. v. figs. 1–4. The type specimen is preserved in the collection of John Ward, Esq., Longton, and was obtained from the Knowles Ironstone (Coal-Measures), Fenton, North Staffordshire.

Elonichthys semistriatus, Traquair.

1873. *Pygopterus*, T. P. Barkas, Coal Meas. Palæont. p. 37, fig. 130 (? fig. 131).

1877. *Elonichthys semistriatus*, R. H. Traquair, Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), p. 49, pl. iii. figs. 9–12, pl. iv. figs. 1–3; also Quart. Journ. Geol. Soc. vol. xxxiii. p. 577.

1889. *Elonichthys semistriatus*, H. Bolton, Trans. Manchester Geol. Soc. vol. xx. p. 215.

1890. *Elonichthys semistriatus*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 172, pl. v. fig. 4.

Type. Middle portion of fish; collection of John Ward, Esq.

A very large species, attaining a maximum length of not less than 0·55. Cranial roof-bones tuberculated, facial bones striated, and mandible longitudinally striated. Teeth smooth and slender, with much incurved apices. Fin-rays longitudinally striated; fulcra

very minute. Scales relatively small; those of the flank somewhat deeper than broad; none serrated. Scale-ornament consisting of oblique striæ, simple, bifurcated, or intercalated, extending from the anterior and superior borders and passing postero-inferiorly into either irregular reticulations (on the principal flank-scales) or sparse pittings (on the other scales).

Form. & Loc. Coal-Measures: Staffordshire, Lancashire, and Northumberland.

P. 4468. Left dentary bone; Knowles Ironstone Shale, Fenton, North Staffordshire. *Enniskillen Coll.*

P. 1002. Fragment of squamation; North Staffordshire. *Egerton Coll.*

P. 3431. Two small groups of scales; Longton, North Staffordshire. *Enniskillen Coll.*

P. 3413. Group of scales; Fenton. *Enniskillen Coll.*

P. 1002 a. Imperfectly preserved flank-scales, probably of this species; Longton. *Egerton Coll.*

P. 5200. Pectoral fin and scales; (?) North Staffordshire. *Purchased*, 1885.

Elonichthys peltigerus, Newberry.

1856. *Elonichthys peltigerus*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. p. 98.

1866. *Palæoniscus peltigerus*, Newberry & Worthen, Pal. Illinois, vol. ii. p. 17, woodc. fig. 1.

1873. *Palæoniscus peltigerus*, J. S. Newberry, Rep. Geol. Surv. Ohio, vol. i. pt. ii. p. 345, pl. xxxviii. fig. 1.

1877. *Elonichthys* (?) *peltigerus*, R. H. Traquair, Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), p. 49.

Type. Imperfectly preserved fish; Columbia College, New York.

A species of moderate or small size. Head with opercular apparatus occupying about one quarter of the total length; external bones finely and irregularly striated. Fin-rays longitudinally striated. Scales of moderate size, ornamented with fine, oblique striæ, more or less irregular, branching, and intercalated, and terminating at the hinder border in delicate serrations.

Form. & Loc. Coal-Measures: Ohio and Illinois.

P. 1004. Imperfectly preserved fish, wanting the greater portion

of the head and tail, displaying the squamation with parts of the pelvic, dorsal, and anal fins; Ohio.
Egerton Coll.

P. 1004 a. Fragment of small fish; Cannel Coal, Linton, Ohio.
Egerton Coll.

Elonichthys aitkeni, Traquair.

1874. *Acrolepis*, J. Aitken, Trans. Manchester Geol. Soc. vol. xiii. p. 36.
1886. *Elonichthys aitkeni*, R. H. Traquair, Geol. Mag. [3] vol. iii. p. 440.
1890. *Elonichthys aitkeni*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. p. 174, pl. vi. figs. 9, 12.

Type. Imperfect fish; *olim* J. Aitken Collection.

A species of moderate size, attaining a length of about 0·18. Head with opercular apparatus occupying about one-fifth of the total length; external bones ornamented with more or less wavy striæ, sometimes subdivided into elongated tubercles. Fin-rays relatively slender, with distant articulations, smooth. Scales of moderate size, those of the flank somewhat deeper than broad. Scale-ornament consisting of prominent striæ, somewhat oblique, nearly straight and parallel, rarely bifurcating or intercalated; hinder margin serrated.

Form. & Loc. Culm-Measures: North Devonshire. Millstone Grit: Staffordshire and Yorkshire. Lower Coal-Measures: Staffordshire, Derbyshire, and Lancashire.

30577. Specimen wanting the greater part of the head, the paired fins, and the extremity of the tail, in counterpart; Dalemoor Rake Ironstone, Stanton-by-Dale, Derbyshire.
Purchased, 1856.

30579–80. Fragmentary remains of head and trunk, with pectoral fin; Stanton-by-Dale. *Purchased*, 1856.

P. 851. Fragment of squamation; North Staffordshire.
Egerton Coll.

P. 6100. Well-preserved impression of head, lateral aspect, and anterior scales; Culm-Measures, Instow, North Devonshire. *Purchased*, 1886.

P. 6102. Imperfect head and anterior scales; Instow.
Purchased, 1886.

Elonichthys striatus (Agassiz).

1835. *Amblypterus striatus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 111, pl. iv. *b*. figs. 3–6.
1837. *Amblypterus striatus*, Paterson, Edinb. New Phil. Journ. vol. xxiii. p. 153.
1857. *Rhabdolepis striatus*, F. H. Troschel, Verhandl. naturh. Verein. preuss. Rheinl. u. Westphal. p. 16.
1877. *Cosmoptychius striatus*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 553; and Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), p. 43, pl. ii. fig. 7, pl. iii. figs. 1–8.
1890. *Elonichthys striatus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. pp. 390, 396.

Type. Portions of fishes; Edinburgh Museum.

A species attaining a length of about 0·3. Maximum depth of trunk in advance of dorsal fin contained somewhat less than four times in the total length. Head with opercular apparatus occupying about one-fifth of the total length; operculum very deep and narrow; all the external bones delicately striated. Fin-rays obliquely striated; dorsal and anal fins equal in size and form. Scales of the middle of the flank nearly twice as deep as broad; none posteriorly serrated. Scale-ornament consisting of fine, irregular, oblique striæ.

This is the type species of the so-called *Cosmoptychius*.

Form. & Loc. Calciferous Sandstones: S.E. Scotland.

P. 1012, P. 3446. A small nodule with part of squamation, and two portions of nodules with scattered scales and an imperfect head; Wardie, near Edinburgh.

Egerton & Enniskillen Colls.

47719. Imperfectly preserved head, opercular apparatus, anterior portion of the abdominal region, and paired fins; Burdiehouse, near Edinburgh. A few of the large slender teeth are observed in the front of the mandible, and the scale-ornament is well exhibited.

Presented by Dr. Lauder Lindsay, 1876.

P. 846 b. Group of scales; Burntisland, Fifeshire. *Egerton Coll.*

Elonichthys macropterus (Bronn).

1829. *Palæoniscum macropterum*, H. G. Bronn, Zeitschr. f. Mineral. vol. ii. p. 483.
1833. *Amblypterus macropterus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 4, 31, pl. i. figs. 4–7, pl. iii. figs. 1–4.

1833. *Amblypterus eupterygius*, L. Agassiz, *ibid.* pp. 4, 36, pl. i. fig. 8, pl. iii. figs. 5, 6. [Stuttgart Museum.]
1847. *Amblypterus macropterus*, Goldfuss, Beitr. vorweltl. Fauna Steinkohlengeb. p. 20, pl. v. figs. 1–8.
1848. *Amblypterus macropterus*, C. G. Giebel, Fauna der Vorwelt, Fische, p. 252.
1848. *Amblypterus eurypterygius*, C. G. Giebel, *ibid.* p. 253.
1857. *Rhabdolepis macropterus*, F. H. Troschel, Verhandl. naturh. Verein. preuss. Rheinl. u. Westphal. p. 15, pl. ii. fig. 15.
1857. *Rhabdolepis eupterygius*, F. H. Troschel, *ibid.* p. 15, pl. ii. fig. 14.
1873. *Amblypterus eupterygius*, F. Goldenberg, Fauna Saræpontana Fossilis, pt. i. p. 5, pl. i. fig. 2.
1877. *Rhabdolepis macropterus*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 552, and Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), pl. ii. fig. 6.

Type. Nearly complete fishes.

A species of moderate [or large] size. Length of head with opercular apparatus nearly equal to the maximum depth of the trunk, which is contained about four and a half times in the total length; opercular apparatus very narrow; cranial roof-bones tuberculated, other external bones striated. Fin-rays longitudinally striated; pelvic fins arising midway between the pectoral and the anal; median fins relatively large, the dorsal and anal of nearly equal size. Scales relatively small, as broad as deep upon the flank, ornamented with irregular delicate oblique striæ, of which two, three, or four at the inferior border of the flank-scales become nearly parallel with that border; hinder border without serrations. This is the type species of *Rhabdolepis*, Troschel.

Form. & Loc. Lower Permian: Rhenish Prussia[1].

15414. Fish in counterpart, 0·12 in length; Lebach.
Purchased, 1840.

15598. Larger specimen, in counterpart, displaying striations upon the maxilla, mandible, and fin-rays; Lebach.
Purchased, 1843.

21529 a. Small robust fish, in counterpart; Lebach.
Purchased, 1847.

22658 b. Two specimens in counterpart; Lebach.
Purchased, 1848.

[1] Fragments of an uncertain species from the Coal-Measures of Wettin, Province of Saxony, are also assigned to the so-called *Amblypterus macropterus* by E. F. Germar, Verstein. Steinkohlengeb. Wettin (1849), p. 73, pl. xxix. figs. 10, 11.

P. 992. Three specimens displaying baseosts of dorsal fin ; Lebach. *Egerton Coll.*

P. 992 a, P. 994, P. 3456–7. Two imperfect specimens, in counterpart, the second showing part of both series of dorsal fin-supports ; Lebach. *Egerton & Enniskillen Colls.*

P. 4353 a. A much crushed fish, 0·11 in length, and a smaller specimen ; Lebach. *Enniskillen Coll.*

P. 6196. Remains of five small fishes ; Lebach. *Goldenberg Coll.*

32576, 32578. Two imperfect fishes about 0·16 in length, the first in counterpart ; Saarbrück. *Purchased*, 1857.

44081. Similar specimen, in counterpart ; Saarbrück. *Purchased*, 1873.

47883. Remains of a similar fish ; Saarbrück. *Presented by the Hon. Robert Marsham*, 1877.

P. 993 a. Small trunk displaying squamation, with portions of the head and fins : Börschweiler. *Egerton Coll.*

P. 993, P. 3455. Two specimens in counterpart ; Börschweiler. *Egerton & Enniskillen Colls.*

P. 6197. Small fish in counterpart, figured by Goldenberg, *op. cit.* *Goldenberg Coll.*

The following specimens are doubtfully regarded as large individuals of this species :—

P. 3456. Imperfect fish, wanting the dorsal fin and the extremity of the caudal, labelled *Amblypterus macropterus* by Agassiz ; Lebach. *Enniskillen Coll.*

P. 992 b. Remains of trunk with all fins except the dorsal ; Lebach. *Egerton Coll.*

P. 2072, P. 3453. Crushed head and trunk, in counterpart, wanting the extremity of the caudal lobe, but originally about 0·42 in length ; Lebach. *Egerton & Enniskillen Colls.*

P. 850, P. 3452. Remains of head and trunk, about 0·33 in length, in counterpart, with portions of the anal, caudal, and pelvic fins ; Börschweiler. *Egerton & Enniskillen Colls.*

P. 3454. Head and anterior portion of trunk, showing an ornament of interrupted striæ and elongated tubercles on some of the external bones ; Castel, near Birkenfeld. *Enniskillen Coll.*

Elonichthys (?) gigas (Fritsch).

1877. *Amblypterus gigas*, A. Fritsch, Sitzungsb. k. böhm. Gesell. Wiss. p. 51.

Type. Imperfect fish; Royal Bohemian Museum.

A species of very large size, attaining a length of not less than 1·3. Maximum depth of trunk somewhat exceeding the length of the head with opercular apparatus, contained about four times in the total length. Scales of flank scarcely deeper than broad, all ornamented with numerous fine oblique striæ.

This species may pertain to *Acrolepis*, but the results of the detailed researches of Fritsch must be awaited before it can be generically determined.

Form. & Loc. Lower Permian: Bohemia.

P. 5855. Plaster cast of type specimen, the original in fragments, to be described with figures in a forthcoming part of Fritsch's 'Fauna der Gaskohle'; Zílov.

Purchased, 1887.

Elonichthys egertoni (Egerton).

1844. *Palæoniscus egertoni*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 302 (name only).

1850. *Palæoniscus egertoni*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. vi. p. 5, pl. i. fig. 2.

1852. *Palæoniscus egertoni*, Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. vi. no. 2, pl. ii.

1870. *Palæoniscus egertoni*, Hancock & Atthey, Nat. Hist. Trans. Northumb. & Durham, vol. iii. p. 96.

1877. *Elonichthys egertoni*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 553, and Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), pl. ii. fig. 8.

1890. *Elonichthys egertoni*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 171, pl. iv. figs. 1, 2.

Type. Imperfect fish; British Museum.

A comparatively slender, small species, attaining a length of about 0·12. Maximum depth nearly equal to the length of the head with opercular apparatus, which occupies about one-fifth of the total length; external bones tuberculated. Fin-rays coarsely ribbed longitudinally, with few delicate oblique striæ. Scales of moderate size, relatively thin, with well-developed internal rib; principal flank-scales somewhat deeper than broad. Scale-ornament

consisting of prominent oblique striæ, irregularly branching and intercalated, terminating at the posterior border in acute serrations.

Form. & Loc. Coal-Measures: Staffordshire, Lancashire, Yorkshire, and Northumberland.

P. 570. Type specimen; Brown-mine Ironstone Shale, Silverdale, N. Staffordshire. *Egerton Coll.*

36889. Fragmentary specimen; Deep-mine Ironstone Shale, Longton, N. Staffordshire. *Purchased*, 1862.

P. 238. Fish imperfect anteriorly, and wanting the upper caudal lobe; Longton. *Weaver-Jones Coll.*

P. 1003. Three fragmentary specimens; Longton. *Egerton Coll.*

P. 3436, P. 4334. Nine specimens, variously preserved; Longton. *Enniskillen Coll.*

P. 5171, P. 5174. Five similar specimens, one in counterpart; Longton. *Purchased*, 1885.

P. 5172. Three imperfect specimens; Fenton, near Longton. *Purchased*, 1885.

P. 5173, P. 5192. Two imperfect specimens; Hanley, North Staffordshire. *Purchased*, 1885.

Elonichthys robisoni (Hibbert).

1835. *Palæoniscus robisoni*, S. Hibbert, Trans. Roy. Soc. Edinb. vol. xiii. p. 191, pl. vi. figs. 6, 7, pl. vii. figs. 1–3.

1835. *Palæoniscus robisoni*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 88, pl. x. *a*. figs. 1, 2.

1835. *Palæoniscus striolatus*, L. Agassiz, *ibid.* p. 91, pl. x. *a*. figs. 3, 4. [Edinburgh Museum.]

1835. *Amblypterus nemopterus*, L. Agassiz, *ibid.* p. 107, pl. iv. *b*. figs. 1, 2. [British Museum.]

1835. *Amblypterus punctatus*, L. Agassiz (*pars*), *ibid.* p. 109, pl. iv. *c*. figs. 3, 5–8.

1837. *Amblypterus nemopterus*, Paterson, Edinb. New Phil. Journ. vol. xxiii. p. 153.

1877. *Elonichthys intermedius*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix. p. 279. [Imperfect fish; Edinburgh Museum.]

1877. *Elonichthys ovatus*, R. H. Traquair, *ibid.* p. 427. [Imperfect fish; Edinburgh Museum.]

1877. *Elonichthys nemopterus*, R. H. Traquair, *ibid.* p. 278, and Quart. Journ. Geol. Soc. vol. xxxiii. p. 553.

1877. *Elonichthys robisoni*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 553.

1877. *Elonichthys striolatus*, R. H. Traquair, *ibid.* p. 553, and Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), p. 57, pl. vii. figs. 4–15.

1880. *Elonichthys tenuiserratus*, R. H. Traquair, Proc. Roy. Phys. Soc. Edinb. vol. v. p. 119. [Imperfect fish; Mus. Comp. Zool., Cambridge, Mass.]

1880. *Elonichthys dunsii*, R. H. Traquair, *ibid.* p. 126. [Imperfect fish; Free Church College Museum, Edinburgh.]

1890. *Elonichthys nemopterus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. pp. 390, 394 (admits varieties *striolatus*, *intermedius*, *dunsii*, *tenuiserratus*, and *affinis*).

Type. Imperfect fish; Edinburgh Museum.

A very variable species, of moderate size. Maximum depth of trunk more than twice that of the caudal pedicle, and equalling nearly one quarter of the total length. Head with opercular apparatus contained about four and a half times in the total length; cranial roof-bones tuberculated, facial bones striated. Fin-rays robust, with close articulations in the adult, finely marked with longitudinal striæ; fulcra minute. Scales of flank scarcely deeper than broad; posterior margin finely serrated. Scale-ornament consisting of very delicate, irregular, oblique striæ, passing behind into reticulations or punctations.

Form. & Loc. Calciferous Sandstones: Midlothian and Fifeshire. Carboniferous Limestone: Midlothian [1].

P. 3428. Well-preserved specimen, 0·145 in length, displaying the dorsal, anal, and parts of the other fins; Calciferous Sandstone, Burdiehouse, near Edinburgh. *Enniskillen Coll.*

20685. Equally large specimen, much crushed and distorted, showing parts of the paired, anal, and caudal fins; Burdiehouse. *Purchased*, 1847.

P. 999. Three young individuals, one imperfect anteriorly; Burdiehouse. *Egerton Coll.*

P. 2827, P. 3432. Three young individuals, somewhat imperfect; Burdiehouse. *Enniskillen Coll.*

P. 3429. Portions of three small individuals; Burdiehouse. *Enniskillen Coll.*

[1] Under the name of *Palæoniscus striolatus*, Ag., an uncertain species from the Coal-Measures of Löbejün, Province of Saxony, is also described by E. F. Germar, Verstein. Steinkohlengeb. Wettin (1849), p. 79, pl. xxix. fig. 12. Another fossil, similarly described as having been obtained from Belgium (L. G. de Koninck, Anim. Foss. Terr. Carb. Belg. 1844, p. 610, pl. liv. figs. 1, 2), is probably a German specimen of *Palæoniscus macropomus* (R. H. Traquair, in L. G. de Koninck's Faune Calc. Carb. Belg. pt. i. p. 13).

P. 3430. Specimen 0·165 in length, from uncertain horizon and locality in Scottish Lower Carboniferous.
Enniskillen Coll.

Var. *a* (*Elonichthys nemopterus*).—Fin-rays relatively slender and distantly articulated; striæ prevalent on scales.

50002. Type specimen of *Amblypterus nemopterus*, Agass., in counterpart; Calciferous Sandstone, Wardie, near Edinburgh. *Trevelyan Bequest.*

P. 1000, P. 3433. Imperfect specimen, in counterpart; Wardie.
Egerton & Enniskillen Colls.

Var. *b* (*Elonichthys intermedius*).—Fin-rays robust, joints longer than broad; scale-ornament delicately striate-punctate.

P. 840. Specimen wanting the pectoral and caudal fins; Wardie.
Egerton Coll.

P. 3435. Imperfect specimen, wanting extremity of tail, in counterpart; Wardie. *Enniskillen Coll.*

Var. *c* (*Elonichthys affinis*).—As var. *intermedius*, but fins smaller and with fewer rays.

P. 841. Imperfect small trunk, with fins; Carboniferous Limestone (Edge-Coal Series), Wallyford, Edinburgh. *Egerton Coll.*

P. 841 a. Small, comparatively well-preserved specimen; Edge-Coal Series, Wallyford. *Egerton Coll.*

Elonichthys bucklandi (Agassiz).

1835. *Pygopterus bucklandi*, L. Agassiz, in S. Hibbert, Trans. Roy. Soc. Edinb. vol. xiii. p. 217, pl. vii. fig. 2.
1844. *Pygopterus bucklandi*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 77.
1877. *Elonichthys bucklandi*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. pp. 553, 575, and Proc. Roy. Soc. Edinb. vol. ix. p. 428.
1890. *Elonichthys bucklandi*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. pp. 390, 394.

Type. Imperfect fish; unknown.

A large species, attaining a length of not less than 0·3. Mandible irregularly striated; laniary teeth very strong, smooth, and incurved. Fin-rays broad and robust, with very close articulations, marked with fine longitudinal striations; fulcra minute. Scales relatively small, those of the flank scarcely deeper than broad;

posterior margin finely serrated. Scale-ornament consisting of delicate, subparallel striæ, oblique and gently sigmoidal, tending to reticulation posteriorly, or replaced by a punctate area, especially above the diagonal between the two acute angles of the scales.

This species is not clearly distinguished by the definition from the adult *E. robisoni*, but it is stated by Traquair to be recognizable "by the strongly marked and deeply cut ornament of its scales."

Form. & Loc. Calciferous Sandstones: Midlothian and Fifeshire. Carboniferous Limestone (Blackband Ironstone): Loanhead, near Edinburgh.

P. 1001. Scattered remains of fish, in counterpart; Calciferous Sandstone, Burdiehouse, near Edinburgh. *Egerton Coll.*

P. 1001 a. A similar smaller specimen; Burdiehouse. *Egerton Coll.*

P. 4396. Portion of caudal region; Burdiehouse. *Enniskillen Coll.*

P. 4397. Imperfect caudal region; Burntisland, Fifeshire. *Enniskillen Coll.*

Elonichthys pulcherrimus, Traquair.

1881. *Elonichthys pulcherrimus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 24, pl. i. figs. 9–12.

Type. Fish, wanting all fins except the dorsal; Geological Survey of Scotland, Edinburgh.

A species of moderate size, attaining a length of not less than 0·15. Length of head with opercular apparatus equal to the maximum depth of the trunk, contained about four and a half times in the total length; cranial roof-bones closely tuberculated, facial bones ornamented with striæ passing into tubercles on the margin of the upper jaw. Fin-rays robust, longitudinally striated. Scales of moderate size, those of the flank scarcely deeper than broad; all finely ornamented and with delicate posterior serrations. Scale-ornament consisting of delicate transverse striæ, more or less oblique on the flank, and somewhat reticulated in the caudal region; enlarged dorsal ridge-scales marked with regularly concentric striæ.

Form. & Loc. Calciferous Sandstone (Cement-stone Group): Eskdale, Dumfriesshire.

P. 5119. Imperfect fish, exhibiting the dorsal fin and part of the caudal. *Purchased*, 1886.

Elonichthys serratus, Traquair.

1881. *Elonichthys serratus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 22, pl. i. figs. 5–8.

Type. Imperfect fish; Geological Survey of Scotland.

A small species, attaining a length of about 0·1. Cranial roof-bones in part granulated; other head-bones and pectoral arch irregularly striated. Fins relatively small, the rays sparsely striated longitudinally. Scales small, those of the flank somewhat deeper than broad; all exhibiting a very coarsely serrated posterior margin. Ornament of principal scales consisting of very delicate, irregular, oblique striæ anteriorly, with large, parallel, oblique ridges posteriorly, these terminating in the hinder serrations.

Form. & Loc. Calciferous Sandstone (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4062. Imperfect small individual, in counterpart, wanting the pelvic, dorsal, and caudal fins. *Purchased*, 1883.

Elonichthys (?) portlocki (Egerton).

1850. *Amblypterus portlocki*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. vi. p. 2.

1877. *Elonichthys portlockii*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 553.

Type. Detached scales, &c.; British Museum (in part).

A species known only from scales and other fragments. Fin-rays longitudinally striated; fulcra prominent. Flank-scales scarcely deeper than broad, ornamented with fine oblique striæ, straight, subparallel, rarely intercalated, and passing behind into serrations of the posterior margin.

Form. & Loc. Lower Carboniferous: Derry and Fermanagh, Ireland.

P. 3460. Two groups of scales, one with imperfect pectoral and anal fins; Maghera. The anal fin-rays are distinctly striated. *Enniskillen Coll.*

The following species have also been determined, but there are no examples in the Collection:—

Elonichthys binneyi, R. H. Traquair, Geol. Mag. [3] vol. v. (1888), p. 251.—Lower Coal-Measures (Dalemoor-Rake Ironstone); Stanton-by-Dale, Derbyshire. [Imperfect fish; E. W. Binney Collection.]

Elonichthys microlepidotus, R. H. Traquair, Geol. Mag. [3] vol. iii. (1886), p. 441 ; J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. (1890), p. 174, pl. vi. fig. 1.—Coal-Measures (Knowles Ironstone Shale); Longton, North Staffordshire. [Imperfect fish ; collection of John Ward, Esq.]

Elonichthys multistriatus, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. (1890), p. 396.—Carboniferous Limestone; Edinburgh. [Fragment; collection of Dr. R. H. Traquair.]

Elonichthys oblongus, R. H. Traquair, Ganoid Fishes Brit. Carb. Form. (Pal. Soc. 1877), p. 55, pl. vi. figs. 1, 2; J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. (1890), p. 173.—Coal-Measures (Knowles Ironstone Shale); Fenton, North Staffordshire. [Imperfect fish; collection of John Ward, Esq.]

Elonichthys pectinatus, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. ix. (1877), p. 430, and Proc. Roy. Phys. Soc. Edinb. vol. v. (1880), p. 121, and Geol. Mag. [2] vol. ix. (1882), p. 545, and Trans. Edinb. Geol. Soc. vol. v. (1887), p. 315. —Calciferous Sandstones and Carboniferous Limestone; Midlothian and Fifeshire. [Fish; Edinburgh Museum.]

The following teeth, described under the name of *Ganacrodus hastula*, R. Owen (Trans. Odontol. Soc. vol. v. 1867, p. 349, pl. vi.), are also probably referable to *Elonichthys* :—

P. 6241. Type specimen, a microscopical section, figured *loc. cit.* figs. 1, 2; Coal-Measures (Low Main Seam), Newsham, near Newcastle-upon-Tyne.

Presented by Sir Richard Owen, K.C.B., 1890.

P. 6242. Similar microscopical section, figured *ibid.* figs. 3, 4; Newsham. *Presented by Sir Richard Owen, K.C.B.*, 1890.

These fossils were assigned to *Palæoniscus* by Hancock & Atthey, Nat. Hist. Trans. Northumb. & Durham, vol. iii. (1870), p. 100.

Doubtful and imperfectly defined species have also been named as follows :—

Elonichthys crassidens, C. G. Giebel, Fauna der Vorwelt, Fische (1848), p. 251; E. F. Germar, Verstein. Steinkohlengeb. Wettin (1849), p. 77, pl. xxx. figs. 5, 6.—Coal-Measures; Wettin. [Jaws; University Museum, Halle.]

Elonichthys lævis, C. G. Giebel, *ibid.* p. 251; E. F. Germar, *ibid.* p. 78, pl. xxx. figs. 7, 8.—Coal-Measures; Wettin. [Mandibular ramus; University Museum, Halle.]

Elonichthys browni, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. (1877), p. 553: *Palæoniscus* (*Elonichthys*) *brownii*, J.W. Dawson, Canadian Nat. n. s. vol. viii. (1877), p. 339, and Acadian Geology, Suppl. (1878), p. 101: *Palæoniscus brownii*, C. T. Jackson, Rep. Albert Coal Mine (1851), p. 22, pl. i. fig. 2, and Proc. Boston Soc. Nat. Hist. vol. iv. (1852), p. 139.—Lower Carboniferous; Hillsborough, Albert Co., New Brunswick.

Elonichthys speciosus: *Gyrolepis speciosus*, A. Fritsch, Sitzungsb. k. böhm. Gesell. Wiss. 1877, p. 46.—Lower Permian (Gas-coal); Bohemia. [Jaws and scales; Royal Bohemian Museum, Prague.]

Here possibly may also be placed the undescribed species, *Propalæoniscus agassizi*, A. Pomel (Catal. Méthod. Vert. Foss. 1853, p. 133), from the Coal-Measures of Bert-Montcombroux, Allier.

Genus **ACROLEPIS,** Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1833, p. 11, and *ibid.* pt. ii. 1844, p. 79.]

Trunk elongated, gradually tapering from the occiput. Mandibular suspensorium oblique; dentition consisting of a series of large, well-spaced conical teeth, and more numerous small teeth irregularly arranged and somewhat clustered; head and opercular bones strongly ornamented with tuberculations, often fused into short vermiculating rugæ and striæ. Fins well developed, with fulcra, the rays branching distally, covered with dense ganoine, and the more robust sculptured. Pelvic fins with comparatively short base-line, dorsal and anal fins triangular, at least as high as long, the dorsal opposed to the space between the pelvic and anal fins; upper caudal lobe robust, the fin deeply forked and equilobate. Scales thick, large, or of moderate size, deeply imbricating, externally enveloped in dense ganoine, sculptured with coarse oblique grooves and ridges, sometimes bifurcating; flank-scales rarely deeper than broad, ventral scales narrow; the large scales of the caudal pedicle extending well up the base of the superior caudal lobe.

The known species of this genus are all of large size.

Acrolepis sedgwicki, Agassiz.

1829. "Fossil Fish," A. Sedgwick, Trans. Geol. Soc. [2] vol. iii. p. 117, pl. viii. figs. 3, 4.

1833. *Acrolepis sedgwicki*, L. Agassiz, Neues Jahrb. p. 476, and Poiss. Foss. vol. ii. pt. i. p. 11.
1833. *Gyrolepis asper*, L. Agassiz, *ibid.* p. 473, and *ibid.* p. 6.
1835. *Acrolepis sedgwickii*, F. A. Quenstedt, Wiegmann's Archiv. Naturg. vol. ii. p. 92.
1839. *Palæoniscus dunkeri*, G. A. Kurtze, Comment. Petrefact. Mansfeld. pp. 16, 37, pl. i.
1840. *Palæoniscus dunkeri*, E. F. Germar, Verstein. Mansfeld. Kupferschief. p. 19, figs. 1-5.
1841. *Acrolepis asper*, L. Agassiz, Neues Jahrb. p. 614. [British Museum.]
1842. *Acrolepis dunkeri*, G. von Münster, Beitr. Petrefakt. pt. v. p. 40.
(?) 1842. *Acrolepis angustus*, G. von Münster, *ibid.* p. 40. [Palæontological Museum, Munich.]
(?) 1842. *Acrolepis giganteus*, G. von Münster, *ibid.* p. 41. [Ditto.]
1844. *Acrolepis sedgwickii*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 80, pl. lii. (plate published 1839).
1844. *Acrolepis asper*, L. Agassiz, *ibid.* p. 81.
1848. *Acrolepis sedgwickii*, C. G. Giebel, Fauna der Vorwelt, Fische, p. 241.
1848. *Acrolepis asper*, C. G. Giebel, *ibid.* p. 241.
1850. *Acrolepis sedgwickii*, Sir P. Egerton, in King's Permian Foss. (Pal. Soc.), p. 234, pl. xxv.
1861. *Acrolepis sedgwicki*, H. B. Geinitz, Dyas, p. 13.
1861. *Acrolepis asper*, *angustus*, and *giganteus*, H. B. Geinitz, *ibid.* pp. 13, 14.

Type. Caudal portion of fish; *olim* Witham Collection.

The type species, attaining a length of about 0·7. Maximum depth of trunk contained about six times in the total length. Head and opercular apparatus occupying one-fifth of the total length; snout obtusely pointed; hinder expansion of maxilla three quarters as high as broad, truncated above, its postero-inferior portion produced downwards in a small rounded expansion, bearing smaller teeth than the other part of the dentigerous border; large teeth short and stout, but acutely pointed; ornamentation of cranial, facial, and opercular bones almost uniform, consisting of coarse tuberculations, with a tendency towards elongation and partial fusion into parallel rugæ; tubercles of rostral region mostly rounded, those bordering the jaws the smallest. Pelvic fins about half as large as the pectorals, situated much nearer to the anal than to the latter; dorsal and anal fins deeper than long, of nearly equal size, the dorsal precisely opposed to the space between the pelvic fins and the anal, to which its base-line is almost equal in extent. Scale-ornament very coarse, the flank-scales each marked by about six broad, rounded, antero-posterior ridges, of which those on the

abdominal region are nearly parallel, while those on the caudal region gradually converge towards the postero-inferior angle of the scale, and thus exhibit a branched arrangement.

The supposed differences in the scale-ornament and the sculpture of the ganoine on the caudal fin-rays noted by Agassiz in *A. sedgwicki* and the so-called *A. asper*, appear from later discoveries to be entirely due to differences in the state of preservation.

Form. & Loc. Upper Permian (Marl Slate): Durham. Upper Permian (Kupferschiefer) : Germany.

(i.) *Marl Slate.*

P. 3407. Fish 0·65 in length, lateral aspect, exhibiting large portions of all the fins except the dorsal; Midderidge. The form of the maxilla is distinct, and the ornamentation of most of the head and opercular bones is displayed. Much of the squamation is preserved, but the majority of the scales are seen from the inner aspect, while others are indicated as mere impressions of the external ornamented surface. *Enniskillen Coll.*

P. 553. Posterior half of abdominal region and the tail, with fins, noticed and figured by Egerton, *loc. cit.* 1850 ; Ferry Hill. *Egerton Coll.*

P. 3406. Imperfect caudal region, wanting the anal fin and the greater portion of the dorsal, associated with some scattered head-bones ; Ferry Hill. One of the small pelvic fins is also observed anteriorly. *Enniskillen Coll.*

(ii.) *Kupferschiefer.*

P. 3411. Type specimen of *Acrolepis asper* described by Agassiz, agreeing in size and proportions with no. P. 3407 ; Mansfeld, Thuringia. Many parts of the fossil are somewhat obscured by a thin film of matrix. The suboperculum and branchiostegal rays are well shown ; and of the fins only the distal portions of the anal and caudal are broken away. The ganoine-coated articulations of the fin-rays were mistaken by Agassiz, as in some other Palæoniscidæ, for an investment of ganoid scales. *Enniskillen Coll.*

15401. Imperfect head, opercular apparatus, and anterior scales ; Thuringia. *Purchased*, 1840.

15511. Obscure remains of head, opercular apparatus, pectoral arch and fin, and some anterior scales; Eisleben, Province of Saxony. The principal rays of the pectoral fin appear to have been unarticulated. *Presented by T. S. Law, Esq.*

43434. Left maxilla and mandibular ramus, associated with other bones, much obscured by matrix; Riechelsdorf, Hesse. *Presented by Kenneth Murchison, Esq.*, 1872.

1992. Imperfect trunk wanting the head, pectoral and dorsal fins, and showing only fragments of the other fins; Mansfeld. *Purchased*, 1837.

P. 2064. Greater portion of trunk, imperfectly preserved, wanting the extremity of the tail, and the anal fin obscured by matrix; Eisleben. *Egerton Coll.*

P. 836. Portion of squamation with anal fin, in counterpart; Eisleben. *Egerton Coll.*

15411. Six portions of the trunk, chiefly caudal region, one exhibiting a good impression of the scales at the base of the caudal lobe, indicating the upward extension of the body-scales; Eisleben. *Purchased*, 1840.

43432. Imperfect caudal fin; Riechelsdorf. *Presented by Kenneth Murchison, Esq.*, 1872.

P. 3405. Much crushed remains of the head, scattered scales, a portion of the vertebral axis, and an impression of one of the fins, probably of this species; Riechelsdorf. The tuberculations upon the head-bones are more completely fused into rugæ than in typical examples of the species; but numerous impressions of scales appear to exhibit the characteristic proportions and ornament. In the fragment of the axial skeleton of the trunk, the space occupied by the notochord is vacant; but there are short, stout neural arches with expanded bases, and a triangular hæmal element is opposed to each. *Enniskillen Coll.*

A species allied to *A. sedgwicki*, from the Magnesian Limestone of Marsden and Fulwell Hill, Durham, not yet satisfactorily defined, is named *A. kirkbyi*, R. Howse, Nat. Hist. Trans. Northumb. and Durham, vol. vii. (1878), p. 171 (previously described by J. W. Kirkby as *A. sedgwicki* in Ann. Mag. Nat. Hist. [3] vol. ix. 1862, p. 269, and as *Acrolepis*, sp., in Quart. Journ. Geol. Soc. vol. xx.

1864, p. 350). The type specimen is an imperfect fish in the Museum of Newcastle-upon-Tyne.

Two portions of large fishes, also closely resembling *A. sedgwicki*, from the Permian of Kargala, Govt. of Orenburg, Russia, are described thus:—

Acrolepis macroderma, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xxx. (1857), pt. ii. p. 349, and Leth. Rossica, vol. i. (1860), p. 1579, pl. lvi. fig. 9.

Acrolepis rhombifera, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1580, pl. lvi. fig. 8.

Acrolepis exsculpta (Kurtze).

1839. *Palæoniscus exsculptus*, G. A. Kurtze, Comment. Petrefact. Mansfeld. p. 19, pl. ii. fig. 1.

1840. *Palæoniscus exsculptus*, E. F. Germar, Verstein. Mansfeld. Kupferschief. p. 21, figs. 6–8.

1842. *Acrolepis ornatus*, G. von Münster, Beitr. Petrefakt. pt. v. p. 41. [Palæontological Museum, Munich.]

1842. *Acrolepis exsculptus*, G. von Münster, *ibid.* p. 42, pl. vi. fig. 2.

(?) 1842. *Acrolepis intermedius*, G. von Münster, *ibid.* p. 41. [Palæontological Museum, Munich.]

1844. *Pygopterus humboldti*, L. Agassiz (*errore*), Poiss. Foss. vol. ii. pt. ii. p. 74.

1848. *Acrolepis exsculptus*, C. G. Giebel, Fauna der Vorwelt, Fische, p. 242.

1861. *Acrolepis exsculptus*, H. B. Geinitz, Dyas, p. 14.

1889. *Acrolepis exculptus*, R. Howse, Guide Local Foss. Mus. Newcastle-upon-Tyne, p. 24.

Type. Imperfect caudal pedicle and fin.

[Form and proportions probably as in the type species.] Tuberculations of head and opercular bones frequently fused into short ridges. Median fins well ornamented with tuberculations, those of the anterior rays elongated. Scale ornament relatively fine, the ridges sharp and irregular, rarely reticulating on the abdominal flank-scales, but frequently so on the caudal; ridges of principal flank-scales often bifurcated, often with intercalations, finest, most numerous, and most frequently interrupted towards the hinder border; ridges of caudal scales becoming gradually more branched and reticulated towards the hinder extremity.

Form. & Loc. Upper Permian (Kupferschiefer): Germany. Upper Permian (Marl Slate): Durham.

P. 6299. Remains of head and abdominal region, with impressions of the neural arches and traces of a series of small hæmal

elements; Eisleben, Province of Saxony. Some of the scales and their ornamentation are well displayed.

38588. Bones of the head associated with the imperfect caudal region; Riechelsdorf, Hesse. Impressions of the maxilla and mandible are distinct, and the ornament of several of the other bones is well shown. *Purchased*, 1864.

P. 837. Two imperfect examples of the head, one connected with part of the abdominal region and the pectoral fin; Riechelsdorf. *Egerton Coll.*

P. 3410. Much abraded remains of head and trunk; Mansfeld, Thuringia. There is a large median scale in the anal region, obtusely pointed in front, with a narrow, smooth area anteriorly, but ornamented on the greater portion of its external surface as the principal scales of the flank. *Enniskillen Coll.*

P. 848. Greater portion of trunk with dorsal, anal, and pelvic fins, all displaying the characteristic ornamentation; Eisleben. *Egerton Coll.*

P. 3410 a. Portion of large trunk and dorsal and anal fins; Eisleben. *Enniskillen Coll.*

P. 5141. Group of scales; Marl Slate, Midderidge, Durham. *Presented by William Dinning, Esq.*, 1886.

Acrolepis hopkinsi, M'Coy.

1844. *Gyrolepis rankinei*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 303 (name only).
1844. *Holoptychius hopkinsii*, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. p. 2.
1855. *Acrolepis hopkinsii*, F. M'Coy, Brit. Palæoz. Foss. p. 609, pl. iii. G. fig. 10.
1877. *Acrolepis hopkinsii*, R. H. Traquair, Quart. Journ. Geol. Soc. vol. xxxiii. p. 571.
1877. *Acrolepis rankinei*, R. H. Traquair, *ibid.* p. 571. [Imperfect fish; collection of Dr. J. R. S. Hunter, Braidwood.]
1890. *Acrolepis hopkinsi*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 398.

Type. Scales; Woodwardian Museum, Cambridge.

Scales relatively larger than in the known Permian species, and finely ornamented; superficial ridges of principal flank-scales prominent though small (about five to the space of 0·035), oblique, occa-

sionally branching and anastomosing, or, where two diverge, another being intercalated between; ridges of caudal scales sometimes fused at intervals into a reticulation towards the postero-superior and antero-inferior obtuse angles.

Form. & Loc. Lower Carboniferous: Derbyshire, Yorkshire, Lanarkshire, and Belgium.

P. 849. Scales; Yoredale Rocks, Hebden Bridge, Yorkshire. *Egerton Coll.*

P. 3409. Scales; Hebden Bridge. *Enniskillen Coll.*

P. 3412. Group of scales; Carluke, Lanarkshire. *Enniskillen Coll.*

28753. Group of large scales; Chokier, Belgium. *Purchased*, 1853.

Acrolepis wilsoni, Traquair.

[Plate XV. fig. 3.]

1888. *Acrolepis wilsoni*, R. H. Traquair (*ex* J. Ward, MS.), Geol. Mag. [3] vol. v. p. 254.

Type. Scales; British Museum.

A large species, known only by the scales mentioned below. Ornamental ridges of flank-scales large and broad, marked with very fine longitudinal striations, and so frequently connected one with another by short cross-ridges as to impart to the exposed surface a pitted appearance.

Form. & Loc. Yoredale Rocks: Derbyshire.

P. 5329. Group of twelve scales and bone-fragments, the type specimen; from shales in Yoredale series of Turnditch, near Belper. The best-preserved scale is shown, of twice the natural size, in Pl. XV. fig. 3.

Presented by Edward Wilson, Esq., 1887.

Acrolepis semigranulosa, Traquair.

1890. *Acrolepis semigranulosus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 398.

Type. Scales; Edinburgh Museum.

Scales relatively large, "covered with innumerable oblique, closely-set, fine ridges, often tortuous, and tending constantly to break up into tubercles."

Form. & Loc. Calciferous Sandstone: Straiton, near Edinburgh.

Not represented in the Collection.

Acrolepis ortholepis, Traquair.

1884. *Elonichthys ortholepis*, R. H. Traquair, Geol. Mag. [3] vol. i. p. 10.

1890. *Acrolepis ortholepis*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 398, and Ann. Mag. Nat. Hist. [6] vol. vi. p. 492.

Type. Immature fish; British Museum.

A species of moderate size. Trunk robust; head with opercular apparatus contained about four and a half times in the total length. Scales of flank deeper than broad, all coarsely ornamented, none posteriorly serrated. Scale-ornament consisting of thick ridges parallel with the superior, inferior, and posterior borders, meeting at acute angles on a strong diagonal ridge, which extends downwards and backwards across the scale to the postero-inferior angle.

Form. & Loc. Calciferous Sandstone (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4081. Type specimen, being a young individual 0·32 in length, imperfectly preserved in counterpart. *Purchased*, 1883.

Acrolepis (?) hortonensis, Dawson.

1868. *Acrolepis hortonensis*, J. W. Dawson, Acadian Geology, ed. 2, p. 254, fig. 77, *e*, *f*.

(?) 1877–78. *Palæoniscus jacksoni*, J. W. Dawson, Canadian Nat. n. s. vol. viii. p. 339, and Acadian Geology, Suppl. p. 101. [Imperfect trunk; Peter Redpath Museum, Montreal.]

Type. Fragment of jaw and detached scales; Peter Redpath Museum, Montreal.

A species provisionally assigned to this genus, and known only by fragments. Laniary teeth relatively very large and broad. Scales sculptured with numerous oblique ridges.

Form. & Loc. Lower Carboniferous: Nova Scotia.

P. 6218. Guttapercha cast of type specimen, a fragment of mandible; Horton Bluff.

Presented by Sir J. William Dawson, 1890.

Acrolepis (?) digitata, sp. nov.

[Plate XV. fig. 4].

Type. Group of scales; British Museum.

This provisional name is suggested for the specimens mentioned

below. The superficial layer of ganoine upon each scale terminates in a series of irregular digitations at the anterior overlapped border, and is only marked in the posterior half by sparse, elongated pits; the hinder border exhibits a series of very large, downwardly directed denticulations.

These scales only differ essentially from those of the typical *Acrolepis* in the presence of posterior denticles—a character usually only of specific value.

Form. & Loc. Karoo Formation: South Africa.

47080. The type specimen, being a group of scales of moderate size, some well-preserved, and one shown, enlarged twice, in Pl. XV. fig. 4; Graaf Reinet District, Cape Colony.
Rubidge Coll.—Presented by the Hon. W. Guybon Atherstone, M.D., 1875.

P. 6300. Plaster cast of portion of squamation, the original in the Albany Museum, Cape Colony; Koomes River, Fish River, Cape Colony. *Made in the Museum*, 1876.

Scales and other fragments, evidently in part of this genus, have also been described as follows:—

Acrolepis (?) *africana*, R. H. Traquair, in H. Drummond, Tropical Africa (1888), p. 194.—N.W. shore of Lake Nyassa.

Acrolepis (?) *drummondi*, R. H. Traquair, *ibid.* p. 193.—Ibid.

Acrolepis murchisoni, E. von Eichwald, Leth. Rossica, vol. i. (1860), p. 1581: *Tetragonolepis murchisoni*, G. Fischer de Waldheim, Bull. Soc. Imp. Nat. Moscou, vol. xv. (1842), pt. ii. p. 463.—Permian Conglomerate; Troitzk, Govt. of Orenburg, Russia. [?Includes *Amblypterus orientalis*, Eichw.: see p. 448.]

Acrolepis reticulata, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xix. (1846), pt. ii. p. 299, pl. x. figs. 38, 39, and Leth. Rossica, vol. i. (1860), p. 1578, pl. lv. fig. 14.—Old Red Sandstone; near Orel, Russia. [? *Glyptopomus.*]

An unknown fossil from the Carboniferous of Carluke, Lanarkshire, is also named, without description, *Acrolepis acutirostris*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. (1844), p. 162.

Genus **GYROLEPIS**, Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1833, pp. 6, 172, and *ibid.* pt. ii. 1844, p. 285.]

Trunk elongate-fusiform. Mandibular suspensorium oblique; dentition comprising an irregular series of well-spaced conical laniaries; opercular apparatus narrow, the operculum being especially deep; all the external head and opercular bones finely ornamented with striæ and tubercles. Fins well developed, with small fulcra. Rays bifurcated, those of the pectoral fins stout and unarticulated, except at their distal extremities; pelvic fins longer than deep; dorsal fin triangular and elevated, arising in advance of, but partly opposed to, the anterior portion of the much extended anal; [caudal fin unknown.] Scales of moderate size, narrowed ventrally, and not much deepened on the flank; externally ornamented with striations.

The foregoing definition is based upon the researches of W. Dames [1], who also interprets one specimen as proving the fusion of the pair of infraclavicles in the median line.

Gyrolepis albertii, Agassiz.

1835. *Gyrolepis albertii*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 173, pl. xix. figs. 1–6.
1835. *Gyrolepis tenuistriatus*, L. Agassiz, *ibid.* p. 174, pl. xix. figs. 10, 11 (? fig. 12).
1835. *Gyrolepis maximus*, L. Agassiz, *ibid.* p. 175, pl. xix. figs. 7–9.
1837. *Gyrolepis tenuistriatus*, H. B. Geinitz, Beitr. Kenntn. Thüring. Muschelkalkgeb. p. 21, pl. iii. fig. 4.
1843. *Gyrolepis tenuistriatus*, J. E. Portlock, Rep. Geol. Londonderry, p. 469, pl. xiv. fig. 11.
1843. *Gyrolepis albertii*, J. E. Portlock, *ibid.* p. 469, pl. xiv. figs. 12–14.
1844. *Gyrolepis albertii*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 285.
1844. *Gyrolepis tenuistriatus*, L. Agassiz, *ibid.* p. 285.
1844. *Gyrolepis maximus*, L. Agassiz, *ibid.* p. 285.
1844. *Gyrolepis albertii*, Meyer & Plieninger, Beitr. Palæont. Württembergs, p. 109, pl. xii. figs. 40, 45.
1844. *Gyrolepis tenuistriatus*, Meyer & Plieninger, *ibid.* p. 109, pl. xii. figs. 41, 43, 44, 46–48, 75.
1848. *Colobodus varius*, C. G. Giebel, Fauna der Vorwelt, Fische, p. 181 (in part).
1851. *Gyrolepis albertii*, H. von Meyer, Palæontogr. vol. i. p. 196.
1851. *Gyrolepis tenuistriatus*, H. von Meyer, *ibid.* p. 196.
1864. *Amblypterus decipiens*, F. von Alberti, Ueberbl. Trias Alpen, p. 209.

[1] Palæont. Abhandl. vol. iv. (1888), pt. 2.

1865. *Gyrolepis tenuistriatus*, H. Eck, Form. bunt. Sandst. u. Muschelk. Oberschlesien, p. 122.
1872. *Gyrolepis maximus*, H. Eck, Rüdersdorf u. Umgegend, p. 114.
1872. *Gyrolepis tenuistriatus*, H. Eck, *ibid.* pp. 118, 121.
1872. *Gyrolepis albertii*, R. Etheridge, Proc. Cardiff Nat. Soc. vol. iii. pl. ii. fig. 18.
(?) 1878. *Gyrolepis albertii* (?) and *G. tenuistriatus*, B. Lundgren, Minneskr. Kongl. Fysiogr. Sällsk. Lund, no. v. p. 33, pl. ii. figs. 62, 65–67.
1880. *Amblypterus decipiens*, T. C. Winkler, Archiv. Musée Teyler, vol. ii. p. 129, pl. viii. figs. 28–30.
1888. *Gyrolepis albertii*, W. Dames, Palæont. Abhandl. vol. iv. p. 143, pl. xi. fig. 1, pl. xii. fig. 1, pl. xv. fig. 1.
1889. *Gyrolepis albertii*, A. S. Woodward, Trans. Leicester Lit. & Phil. Soc. n. s. pt. xi. p. 20.

Type. Scales.

The type species, of relatively large size, the head measuring not less than 0·07 in length. Head as deep as broad, and the external bones ornamented with delicate wavy striæ, sometimes subdivided into tuberculations, as upon the cranial roof and the anterior portion of the maxilla; striæ of dentary bone obliquely directed downwards and forwards. Laniary teeth very long, slender, and acutely pointed. Operculum about three times as deep as broad, marked with delicate, horizontal, wavy striæ and elongated tuberculations. Scales with smooth posterior margin, ornamented with numerous obliquely-directed delicate striæ, often wavy, branching or anastomosing, and in the larger anterior flank-scales subdivided into elongated tubercles.

The precise form and proportions of the trunk of this species are as yet unknown, and, so far as Muschelkalk fossils are concerned, the synonymy and definition given above are based upon the researches of W. Dames, *loc. cit.* (1888). The typical scales are referable to the trunk proper; the scales named *G. maximus* occur in the first vertical series immediately behind the pectoral arch; and those termed *G. tenuistriatus* pertain to the upper caudal lobe. The detached scales from the Rhætic formation are provisionally placed here, because they exhibit no distinctive features.

Form. & Loc. Upper Muschelkalk: Germany and East France. Rhætic: Würtemberg, South England, and North Ireland.

1583 a. Scale in Muschelkalk, Laineck, near Bayreuth, Bavaria.
Braun Coll.

P. 6301. Small associated scales; Muschelkalk, Weimar.
Presented by C. Westendarp, Esq., 1884.

P. 4625. Scale; Muschelkalk, Bayreuth, Bavaria. *Enniskillen Coll.*

28472. Large scale, showing wide overlapped area; Lettenkohl, Bibersfeld. *Purchased*, 1853.

28478. Three small scales in matrix; Rhætic Bone-bed, Crailsheim, Würtemberg. *Purchased*, 1853.

28463. Two imperfect scales in matrix; Rhætic, Nellingen, Würtemberg. *Purchased*, 1853.

P. 1044. Three portions of bone-bed with scales; Rhætic, Crailsheim and Hohenheim. *Egerton Coll.*

11206. Small well-preserved scale; Rhætic, Aust Cliff, near Bristol. *Mantell Coll.*

23153 c. Six scales, somewhat abraded; Aust Cliff. *Purchased*, 1849.

P. 3930. Imperfect scale; Aust Cliff. *Enniskillen Coll.*

P. 1043. Ventral scale, labelled *Gyrolepis tenuistriatus* by Agassiz; Rhætic Bone-bed, Axmouth, Devonshire. *Egerton Coll.*

The Collection also comprises several fragments of Rhætic Bone-bed exhibiting scales of *Gyrolepis albertii*, among remains of other genera and species.

Gyrolepis ornata (Giebel).

1848. *Amblypterus ornatus*, C. G. Giebel, Neues Jahrb. p. 152, pl. ii. A. figs. 7–9, and Fauna der Vorwelt, Fische, p. 254.

1848. *Amblypterus decipiens*, C. G. Giebel, *ibid.* p. 154, and *ibid.* p. 255. [Associated head-bones and scales; School of Mines, Freiberg, Saxony.]

1857. *Rhabdolepis ornatus*, F. H. Troschel, Verhandl. naturh. Vereins preuss. Rheinl. u. Westph. vol. xiv. p. 16.

(?) 1865. *Gyrolepis tenuistriatus*, H. Eck, Form. bunt. Sandst. u. Muschelk. Oberschlesien, p. 71.

1888. *Gyrolepis ornatus*, W. Dames, Palæont. Abhandl. vol. iv. p. 140, pl. xi. fig. 2.

Type. Imperfect fish; School of Mines, Freiberg, Saxony.

A smaller species than the type. Trunk much elongated; dorsal fin almost completely in advance of the anal. Scales resembling those of *G. albertii*, but relatively smaller.

The type specimen is re-described by W. Dames, *loc. cit.*, to whom are due the synonymy and definition here adopted.

Form. & Loc. Lower Muschelkalk: Province of Saxony, (?) and Upper Silesia.

Not represented in the Collection.

Gyrolepis quenstedti, Dames.

1888. *Gyrolepis quenstedtii*, W. Dames, Palæont. Abhandl. vol. iv. p. 152, pl. xv. fig. 2.

Type. Caudal region; University of Tübingen.

A smaller species than the type. Trunk elegantly fusiform; dorsal fin arising very slightly in advance of the anal, and the latter fin excessively elongated. Scales relatively small, ornamented with delicate, well-spaced, oblique striæ; hinder margin not serrated.

Form. & Loc. Upper Trias (Lettenkohle): Biebersfeld, Würtemberg. Not represented in the Collection.

Gyrolepis agassizi (Münster).

1835. *Amblypterus agassizii*, G. von Münster, Neues Jahrb. p. 333.
1835. *Amblypterus agassizii*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 105.
1848. *Amblypterus agassizii*, C. G. Giebel, Fauna der Vorwelt, Fische, p. 253.
1857. *Rhabdolepis agassizii*, F. H. Troschel, Verhandl. naturh. Vereins preuss. Rheinl. u. Westph. vol. xiv. p. 16.
1864. *Amblypterus agassizii*, F. von Alberti, Ueberbl. Trias Alpen, p. 210.
1868. *Rhabdolepis* (*Amblypterus*) *agassizi*, R. von Willemoes-Suhm, Neues Jahrb. p. 831.
1888. *Gyrolepis agassizii*, W. Dames, Palæont. Abhandl. vol. iv. p. 137, pl. xiii. fig. 1.

Type. Fish, wanting extremity of tail; counterparts in Palæontological Museum, Munich, and Museum of Natural History, Berlin.

A very small species. Dorsal fin arising slightly in advance of the anal. Scales relatively small, with few well-spaced sharp striæ, in most cases parallel with the superior and inferior margins; hinder margin not serrated.

Form. & Loc. Lower Muschelkalk: Esperstädt, near Schraplau, Province of Saxony.

Not represented in the Collection.

Scales of *Colobodus* are often mistaken for those of *Gyrolepis*, and have frequently been described under this generic name (see Part III.).

The specimens described under the following names are generically indeterminable, but may pertain to *Gyrolepis*:—

Gyrolepis biplicata, G. von Münster, Beitr. Petrefakt. iv. (1841), p. 140, pl. xvi. fig. 15.—Muschelkalk; Tyrol. [Scale.]

Amblypterus latimanus, C. G. Giebel, Fauna der Vorwelt, Fische (1848), p. 255.—Muschelkalk; Esperstädt. [Head and pectoral fin.]

Genus **ATHERSTONIA**, A. S. Woodward.

[Ann. Mag. Nat. Hist. [6] vol. iv. 1889, p. 241.]

Syn. *Hypterus*, R. Owen, Catal. Foss. Rept. S. Africa, 1876, p. ix. (name only).

Trunk fusiform, elongated but robust. Mandibular suspensorium very oblique and gape wide; [teeth unknown]; head and opercular bones externally rugose and tuberculated. Fins powerful, with broad, laterally compressed rays, frequently articulated and distally bifurcated; anterior pectoral fin-rays unarticulated in their proximal half; pelvic fins with an elongated base-line, the dorsal arising between the pelvics and the anal, and the last-named fin remote, much extended. Scales large or of moderate size, externally marked with oblique striæ, and subdivided into smaller scales at the base of the dorsal, anal, and pelvic fins; dorsal margin with a continuous series of very large, deeply overlapping ridge-scales.

Atherstonia scutata, A. S. Woodward.

1876. *Hypterus bainii*, R. Owen, Catal. Foss. Rept. S. Africa, p. ix. (name only).

1889. *Atherstonia scutata*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. iv. p. 242, pl. xiv. figs. 1–3.

Type. Nearly complete fish; British Museum.

The type species, attaining a length of about 0·35. Head with opercular apparatus occupying about one-fifth of the total length. Pelvic fins arising somewhat nearer to the pectorals than to the anal; the latter much larger than the dorsal, and for the greater part behind this fin. Flank-scales slightly deeper than broad; none posteriorly denticulated. Scale-ornament consisting of sharp striæ, often bifurcating and intercalated, slightly oblique on the principal scales of the flank.

Form. & Loc. Beaufort Beds (Lower Karoo Series): Cape Colony, South Africa.

P. 4735. Type specimen; Colesberg.
Presented by the Hon. W. Guybon Atherstone, M.D., 1884.

46007. Imperfect trunk, labelled *Hypterus bainii* in Owen's handwriting; Alice, near Fort Beaufort.
Presented by the Trustees of the Albany Museum, 1873.

36260. Portion of trunk with dorsal ridge-scales and fin; Brak River, Fort Beaufort. *Presented by A. G. Bain, Esq.*, 1862.

Genus **MYRIOLEPIS**, Egerton.

[Quart. Journ. Geol. Soc. vol. xx. 1864, p. 3.]

Trunk fusiform, but robust. Head large, suspensorium oblique and gape wide; dentition comprising a series of large, well-spaced laniaries. Fins well developed, with small fulcra, the rays branching distally and all [except possibly the anterior rays of the pectoral fin] closely articulated. Pectoral fins relatively large; dorsal and anal fins high and triangular, the former opposed to the space between the pelvic pair and the anal; caudal fin deeply cleft, equilobate. Scales very small, obliquely striated, enlarged upon the sides of the upper caudal lobe; ridge-scales of upper caudal lobe prominent.

Myriolepis clarkei, Egerton.

1864. *Myriolepis clarkei*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xx. p. 3, pl. i. fig. 1.

1890. *Myriolepis clarkei*, A. S. Woodward, Mem. Geol. Surv. N. S. Wales, Palæont. no. 4, p. 8, pl. ii. figs. 3, 4, pl. iii. fig. 1.

Type. Imperfect fishes, wanting tail; destroyed by accidental fire, Museum of Geol. Survey, N. S. Wales.

The type species, attaining a length of about 0·45. Maximum depth of trunk nearly equal to the length of the head with opercular apparatus, and contained about five times in the total length. Pelvic fins half as large as the pectoral pair, situated midway between the latter and the anal; dorsal fin somewhat longer than deep; anal fin smaller than the latter, but equally elevated. Scales extremely small, those of the flank in an individual 0·435 in length not measuring more than 0·0015 in depth and breadth.

Form. & Loc. Hawkesbury Beds (Upper Trias): New South Wales.

Not represented in the Collection.

A shorter and stouter species of *Myriolepis*, with relatively larger scales, also from the Hawkesbury Beds, is named *M. lata*, A. S. Woodward, *op. cit.* p. 10, pl. iii. figs. 2, 3. The type specimen is in the Museum of the Geol. Survey of N. S. Wales, Sydney, and there are no examples in the British Museum Collection.

In this genus, perhaps, may also be placed the so-called *Palæoniscus antipodeus*, Sir P. Egerton, Quart. Journ. Geol. Soc. vol. xx. (1864), p. 4, pl. i. fig. 4, and woodc. An imperfect specimen apparently referable to *M. clarkei* has lately been noticed under the same name by O. Feistmantel, Mem. Geol. Surv. N. S. Wales, Palæont. no. 3 (1890), p. 72, pl. xxx. fig. 1.

Genus **OXYGNATHUS,** Egerton.

[Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. viii. 1855, no. 9.]

Syn. *Thrissonotus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. 1844, p. 128 (undefined).
Cosmolepis, Sir P. Egerton, *loc. cit.* dec. ix. 1858, no. 1.

Trunk elegantly fusiform, more or less elongated. Mandibular suspensorium oblique; dentition consisting of a series of large, well-spaced conical teeth, and numerous minute teeth irregularly arranged and somewhat clustered; cranial roof-bones finely tuberculated, sometimes rugose, the facial bones and branchiostegal rays delicately striated, and the opercular bones almost smooth. Fins of moderate size or small, with very minute fulcra, the rays broad, distally bifurcating, and more or less covered with a very thin layer of ganoine; the rays of the pectoral fins, except the few short ones placed hindermost, articulated only at the distal extremities, all others uniformly articulated to the base. Dorsal and anal fins triangular in shape, somewhat longer than high, and the hinder rays very short; dorsal opposed to the space between the pelvic and anal fins; upper caudal lobe narrow and much attenuated, with small ridge-scales, the fin deeply forked and equilobate. Scales thick, small or of moderate size, very narrow ventrally, and ornamented with delicate oblique lines of ganoine, in part bifurcating and branching, becoming very faint upon the anterior dorso-lateral region and partially subdivided into tubercles.

Oxygnathus ornatus, Agassiz.

1844. *Thrissonotus colei*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 128 (name only).
1854. *Oxygnathus ornatus*, Sir P. Egerton, Ann. Mag. Nat. Hist. [2] vol. xiii. p. 435.
1855. *Oxygnathus ornatus*, Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. viii. no. 9, pls. ix., ix.*
1858. *Thrissonotus colei*, Sir P. Egerton, *ibid.* dec. ix. no. 2, pl. ii. [Fish wanting extremity of tail; British Museum.]
1877. *Oxygnathus ornatus*, R. H. Traquair, Ganoid Fishes Brit. Carb. Form. (Pal. Soc.), pl. ii. figs. 2, 3.
1890. *Oxygnathus ornatus*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. p. 432.

Type. Fish wanting dorsal and caudal fins; British Museum.
The type species, attaining a length of about 0·4. Maximum

depth of trunk contained about five and a half times in the total length. Head and opercular apparatus occupying one quarter of the total length; snout acutely pointed; teeth long and slender, sharp, and somewhat bent inwards; tuberculations of cranial roof regular and closely arranged, striæ upon maxilla and mandible also numerous, but irregular, those of the expanded hinder portion of the maxilla chiefly concentric with the posterior and upper margins, those of the mandible chiefly longitudinal, but short, irregularly anastomosing and bifurcating. Pelvic fins two-thirds as large as the pectorals, arising nearer to the anal than to the latter; dorsal fin slightly larger than the anal, terminating opposite the anterior rays of this fin. Scales with prominent, sparse, superficial ridges of ganoine.

Form. & Loc. Lower Lias: Dorsetshire.

P. 3485. Type specimen described by Egerton, and figured *loc. cit.* pl. ix.; Lyme Regis. The pectoral fin-rays are rightly noted as devoid of transverse articulations, though such are indicated by error in the figure; and there is some inaccuracy in the drawing of the superficial ornament of the jaws and branchiostegal rays. The striations upon these bones are not regular and parallel, but elongate lenticular in form, closely interlaced, and apparently sometimes branching. As remarked by Egerton in the appendix to his description, the apparently small size of the anal fin is due to its imperfect state of preservation.

Enniskillen Coll.

P. 557. An almost complete specimen described (with figure of caudal region) by Egerton, *loc. cit.*, appendix, p. 2, pl. ix.*; Lyme Regis. The head is seen partly from beneath, partly from the left side, and displays the jaws, dentition, branchiostegal rays, opercular bones, and a fragment of the cranial roof. The latter bone is tuberculated; the operculum and suboperculum show only lines of growth with a few scattered pittings; and the jaws and branchiostegal rays are characteristically striated. Some inferior external bones, apparently imperfect infraclavicles, are marked with coarse short rugæ and rounded tubercles. The supposed ossified vertebral centra are either small pleurocentra and hypocentra, or (as seems more probable) merely the expanded bases of the arches; and the upper caudal lobe is of the ordinary Palæoniscid and Acipenseroid type. The fins and scales do not require further

description; but it may be added that the ridge-scales upon the caudal lobe appear to have been remarkably small. *Egerton Coll.*

P. 3487. Small imperfectly preserved individual, 0·26 in length; Lyme Regis. The hindermost quarter of the alveolar border of the maxilla inclines sharply downwards and backwards, and bears very slender large teeth directed forwards. The cranial roof is shown to have been closely tuberculated, and there are faint indications of minute, sparsely arranged tubercles on the operculum and suboperculum. Some of the neural and hæmal arches are indicated, and the notochord does not appear to have been even in part surrounded by hypocentra and pleurocentra. The ridge-scales of the upper caudal lobe are well shown, very delicate, narrow, and attenuated. *Enniskillen Coll.*

P. 3487 a. Imperfect fish, 0·37 in length, displaying the inferior aspect of the head, pectoral fins, the impression of a pelvic fin, and the equality of the lobes of the caudal fin; Lyme Regis. *Enniskillen Coll.*

P. 3487 b. Imperfect head and anterior abdominal region of a large fish, lateral aspect, and the extremity of the caudal region perhaps of the same individual, but, if so, from the counterpart slab; Lyme Regis. The clavicle and supraclavicle are observed, ornamented with irregular short striæ and coarser reticulating rugæ; there are small fulcra on the anterior border of the inferior lobe of the caudal fin; and several other characters mentioned above are confirmed. *Enniskillen Coll.*

P. 3487 c. Head and abdominal region, left ventro-lateral aspect, displaying the dentition, opercular apparatus, and paired fins, with a fragment of the anal fin; Lyme Regis. Only the hinder shortest rays of the pectoral fin are articulated, but all the pelvic fin-rays exhibit distant articulations. The suboperculum seems to be nearly equal to the operculum in height, and is much broader. *Enniskillen Coll.*

P. 3487 d–f. Three very imperfect examples of the head and trunk. *Enniskillen Coll.*

P. 872. Imperfect fish, ventral aspect. *Egerton Coll.*

P. 2025. Imperfect head, pectoral fins, and abdominal scales, ventral aspect; Lyme Regis. *Egerton Coll.*

P. 2026. Head, abdominal region, and some of the scales of the caudal region, vertically crushed and showing the dorsal aspect; Lyme Regis. The tubercular ornamentation of the cranial roof and the anterior two-thirds of its pair of longitudinal sensory canals are well exhibited; and there are indications of a series of small ossifications in the axial skeleton of the trunk—evidently the expanded bases of the arches. Of the fins, only the right pectoral and the dorsal are preserved. There is no median series of enlarged dorsal ridge-scales; but the squamation of the anterior dorso-lateral region is well preserved, and the ornamentation is distinctly exhibited. The ridges upon these scales are extremely delicate and frequently interrupted, appearing as series of elongated tubercles.
Egerton Coll.

39860. Imperfect fish, 0·365 in length, ventro-lateral aspect, showing all the fins except the dorsal, and confirming many of the characters mentioned above; Lyme Regis.
Purchased, 1866.

38734. Head and trunk of small fish, ventral aspect, imperfectly preserved and wanting all the median fins. The pelvic fins and one of the pectorals are shown. *Purchased*, 1865.

P. 3509. Imperfectly preserved fish, wanting the extremities of the head and tail; Lyme Regis. This specimen is noticed by Agassiz, and described by Egerton as the type of *Thrissonotus colei*. The fact, however, that the scales are comparatively smooth and exhibit concentric structural lines is due to the preservation of the fossil in a hard nodule; while the supposed great relative length of the anal fin seems to be partly a false appearance, caused to some extent by the displacement of the scales and its hinder fin-rays, and by the loss of the distal extremities of the anterior rays at the margin of the nodule. Traces of the dentition and the characteristic ornament of the jaws and cranial roof are distinguishable. *Enniskillen Coll.*

P. 874. Crushed remains of a large head. *Egerton Coll*

P. 3487 g. Caudal fin. *Enniskillen Coll.*

Oxygnathus egertoni (Egerton).

1858. *Cosmolepis egertoni*, Sir P. Egerton (*ex* Agassiz, MS.), Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. ix. no. 1, pl. i.

1890. *Oxygnathus egertoni*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. p. 432.

Type. Fish wanting greater portion of head and upper caudal lobe; British Museum.

The type species of *Cosmolepis*, attaining a length of about 0·45. Maximum depth of trunk contained about four times in the total length. Head and opercular apparatus occupying nearly one quarter of the total length; [large teeth apparently more robust than in *O. ornatus*]; cranial roof tuberculated, maxilla and dentary striated. Pelvic fins much smaller than the pectorals, arising midway between these fins and the anal; dorsal and anal fins with numerous short rays, resulting in their slight extension posteriorly, the dorsal somewhat larger than the anal and terminating opposite the origin of the latter. Scales with prominent, sparse, superficial ridges of ganoine.

Form. & Loc. Lower Lias: Barrow-on-Soar, Leicestershire.

P. 3508. Type specimen. *Enniskillen Coll.*

P. 585. More imperfectly preserved fish, exhibiting the upper caudal lobe, described and figured by Egerton, *loc. cit.* p. 2, fig. 2. *Egerton Coll.*

P. 5854. Small group of ventral scales.
Presented by Mrs. Etheridge, 1888.

The specimens recorded below may pertain to *Oxygnathus*, but are not generically determinable:—

P. 959 x. Two maxillæ, 0·024 in length, with striated ornament; Stonesfield Slate. *Egerton Coll.*

Genus **CENTROLEPIS**, Egerton.

[Figs. & Descrips. Brit. Organic Remains, dec. ix. (Mem. Geol. Surv. 1858), no. 5.]

Trunk fusiform, robust, and somewhat elongated. Mandibular suspensorium oblique; dentition consisting of an inner series of large conical teeth, well spaced but numerous, and an outer close series of smaller teeth similar in form; head, opercular and bran-

chiostegal bones externally tuberculated or rugose. Fins large, consisting of broad flattened rays, all articulated and distally bifurcating, more or less coated with ganoine; anterior borders fringed with well-developed fulcra. Dorsal and anal fins triangular in shape, elevated, the dorsal opposed to the space between the pelvic fins and the anal; caudal fin bifurcated. Scales thick, of moderate size, and highly ornamented; not much deeper than broad upon the middle of the flank, as deep as broad on the ventral aspect. Each scale of the abdominal region marked in the hinder half by coarse postero-inferiorly directed ridges and sharp denticulations, in its anterior half by few, irregular, more or less interrupted vertical ridges and furrows; the scales of the caudal region coarsely serrated posteriorly, with a few short transverse sculpturings anteriorly.

The form of the upper lobe of the tail in this genus is as yet unknown, but the characters of the head appear to justify its reference to the Palæoniscidæ. In the original description of the fish, the pelvic fin is referred to as anal, and the anterior margin of the latter assigned to the caudal; the supposed absence of an inner keel upon the scales of the flank is also now proved to have been assumed from imperfect evidence.

Centrolepis aspera, Egerton.

1844. *Centrolepis asper*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 304 (name only).

1858. *Centrolepis asper*, Sir P. Egerton, Figs. & Descrips. Brit. Organic Remains (Mem. Geol. Surv.), dec. ix. no. 5, pl. v.

1890. *Centrolepis asper*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. p. 430, pl. xvi. fig. 1.

Type. Portion of head and trunk, with paired fins; British Museum.

The type species, attaining a length of about 0·25–0·3. Maximum depth of trunk equal to length of head with opercular apparatus, and contained nearly four times in the total length; snout prominent and bluntly pointed; teeth long, slender, and acute, sometimes gently curved; cranial roof ornamented with closely arranged rounded tubercles, the posterior expansion of the maxilla with similar tubercles and rugæ, and the mandible with irregular delicate striations, mostly directed longitudinally and sometimes passing into small tubercles; operculum, suboperculum, branchiostegal rays, and exposed portions of the pectoral arch also tuberculated, the clavicle sometimes in part rugose. Pelvic fins not much inferior in size to the pectorals, arising behind the middle

point between the pectorals and the anal; dorsal arising opposite the hindermost rays of the pelvic fins, larger and with more robust rays than the anal fin.

The characters and variations of the scale-ornament in different parts of the body are well shown in no. P. 5594.

Form. & Loc. Lower Lias.

P. 582, P. 3510. The type specimen, in counterpart. The pectoral and pelvic fins, with a fragment of the anal, are shown, the pelvic being mistaken by Egerton for the anal, and the true anal for the caudal. The enlarged figures of scales accompanying the original description are taken from the ventral region. *Egerton & Enniskillen Colls.*

38123. Imperfectly preserved fish, wanting the upper caudal lobe, but showing the general form of the head and trunk, lateral (partly inferior) aspect, and displaying all the fins. The ornamentation of the head, opercular apparatus, and pectoral arch is shown; and many of the flank-scales of the abdominal region, exposed from within, exhibit a sharp vertical keel, immediately anterior to the position of the peg-and-socket articulation. *Purchased*, 1864.

P. 5594. Imperfect head and trunk, wanting fins and the extremity of the caudal region. The remains of the dentition, some of the jaw-bones, and the clavicle are shown, in addition to the squamation of the flanks. A few scales, from the middle of the flank, are figured by the present writer, *loc. cit.* *Harford Coll.*

Genus **CRYPHIOLEPIS,** Traquair.

[Geol. Mag. [2] vol. viii. 1881, p. 491.]

Trunk fusiform. Mandibular suspensorium oblique; dentition consisting of an inner series of well-spaced, conical laniaries, and an outer close series of smaller conical teeth. Fins well developed, consisting of articulated, bifurcating rays, and with fulcra on the anterior border. Dorsal and anal fins elevated, triangular-acuminate, the former opposed to the space between the pelvic fins and the anal; caudal fin deeply forked, inequilobate. Body-scales thin, rounded, but seldom symmetrically so, deeply imbricating, destitute of an inner keel, and the exposed area ornamented with more or less irregular ridges, apparently hollow; scales of upper caudal lobe elongate-rhomboidal.

Cryphiolepis striata, Traquair.

[Plate XVI. fig. 9.]

1881. *Cœlacanthus striatus,* R. H. Traquair, Geol. Mag. [2] vol. viii. p. 37.

1881. *Cryphiolepis striatus,* R. H. Traquair, *ibid.* p. 491.

Type. Detached scales; collection of Dr. R. H. Traquair.

The type species (exact proportions at present unknown). Expansion of maxilla ornamented with closely arranged striæ, mostly parallel with its upper and hinder borders; dentary stout behind, tapering in front, marked with fine, close striæ parallel with the inferior, but oblique to the upper margin; laniary teeth in mandible stout, acutely pointed, and somewhat incurved. Fin-rays longitudinally grooved or striated. Exposed area of body-scales rhomboidal, the ornament consisting of fine, closely arranged, subparallel ridges, proceeding to the hinder border without convergence, rarely bifurcating, but often intercalated; scales of caudal lobe faintly grooved or smooth.

Form. & Loc. Middle Carboniferous Limestone Series (Blackband Ironstone): near Edinburgh.

P. 4116. Group of scales, one shown, of three times the natural size, in Plate XVI. fig. 9; Borough Lee.

Presented by Dr. R. H. Traquair, 1883.

A genus and species from the Lower Permian of Bohemia, closely related to *Cryphiolepis*, is named *Sphærolepis kounoviensis*, A. Fritsch, Sitzungsb. k. böhm. Gesell. Wiss. 1877, p. 46. The type specimens are preserved in the Royal Bohemian Museum, Prague, and will be described in a forthcoming part of Fritsch's 'Fauna der Gaskohle.'

Genus **COCCOLEPIS,** Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1844, p. 300.]

Trunk elegantly fusiform. Mandibular suspensorium oblique; dentition consisting of an inner series of large laniaries flanked externally with minute teeth; external bones tuberculated or rugose. Fins large or of moderate size, the rays of all articulated and branching distally; fulcra minute or absent. Pelvic fins with short base-line; dorsal and anal fins triangular, the former opposed to the space between the latter and the pelvic fins; upper caudal lobe much elongated, the fin deeply cleft and somewhat unsymmetrical. Scales thin and deeply imbricating, ornamented with tuberculations of ganoine.

Coccolepis bucklandi, Agassiz.

1844. *Coccolepis bucklandi*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 300, pl. xxxvi. figs. 6, 7.
1848. *Coccolepis bucklandi*, C. G. Giebel, Fauna der Vorwelt, Fische, p. 150.
1863. *Coccolepis bucklandi* (?=*Liodesmus*), A. Wagner, Abh. math.-phys. Cl. k. bay. Akad. Wiss. vol. ix. p. 709.
1881. *Coccolepis bucklandi*, B. Vetter, Mittheil. k. mineral.-geol. Mus. Dresden, pt. iv. p. 37, pl. i. fig. 2.

Type. Fish; Oxford Museum.

The type species, of small size, known specimens not exceeding 0·075 in length. Maximum depth of trunk comprised more than five times in the total length; head much elongated. Dorsal fin arising in advance of the middle point of the back, relatively large, about as long as deep, and its maximum depth equalling that of the trunk at its point of origin; anal fin small. Scales ornamented externally, each with three longitudinal series of sparse tuberculations.

Form. & Loc. Lower Kimmeridgian (Lithographic Stone): Bavaria.

Not represented in the Collection.

Coccolepis andrewsi, sp. nov.

1890. *Coccolepis andrewsi*, Woodward & Sherborn (*ex* Traquair, MS.), Cat. Brit. Foss. Vertebrata, p. 37.

Type. Fish, wanting pectoral fins; Museum of Practical Geology.

A small species, attaining a length of about 0·06. Maximum depth of trunk contained at least six times in the total length; upper caudal lobe excessively elongated and slender. Fin-rays with distant articulations. Dorsal fin arising slightly in advance of the middle point of the back, opposed to the hinder portion of the pelvic fins, as deep as long, and its maximum depth not exceeding that of the trunk at its point of origin; anal fin scarcely deeper than long, about two-thirds as long as the dorsal, arising completely behind the latter and situated close to the caudal fin. Scales very coarsely granulated; fulcra of upper caudal lobe slender, much elongated, and very numerous.

Form. & Loc. Lower Purbeck Beds: Teffont, near Salisbury.

P. 6302. Posterior abdominal and caudal region of fish, in counterpart. *Presented by Rev. W. R. Andrews*, 1890.

Coccolepis liassica, A. S. Woodward.

1890. *Coccolepis liassicus*, A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. p. 435, pl. xvi. figs. 2–4.

Type. Fish; British Museum.

A species of moderate size, attaining a length of not less than 0·135. Maximum depth of trunk equalling the length of the head with opercular apparatus, and comprised about four and a half times in the total length. Teeth regularly spaced, slender, and curved; cranial and facial bones ornamented with coarse rounded tubercles, rarely elongated and fused into short rugæ, becoming sparse on the opercular bones; suboperculum deeper than broad, much larger than the operculum. Pelvic fins relatively large, arising nearer to the anal than to the pectorals; anterior rays of median fins robust and covered with smooth ganoine; dorsal fin arising at the middle point of the back, opposite the hinder half of the pelvic fins, the length of the fin equalling its maximum depth, which is much less than that of the trunk at its point of origin; anal fin relatively small and low, its height equalling only half that of the dorsal, and its length being only about three-quarters that of the latter. Scales small, externally ornamented with numerous irregularly arranged tubercles.

Form. & Loc. Lower Lias: Lyme Regis, Dorsetshire.

P. 887. Type specimen, figured *loc. cit.* fig. 2. *Egerton Coll.*

P. 6153. Imperfect smaller fish, the head figured *loc. cit.* fig. 3. *Enniskillen Coll.*

39865. Caudal region, somewhat crushed, displaying a few of the scales, and figured *loc. cit.* figs. 4, 4 *a*. *Purchased*, 1866.

Coccolepis australis, A. S. Woodward.

[Described in forthcoming Mem. Geol. Surv. N. S. Wales, Palæont. no. 9.]

Type. Head and abdominal region; Museum of Geol. Surv. N. S. Wales, Sydney.

A very large species, attaining a length of at least 0·35. Maximum depth of trunk comprised about six times in the total length; head longer than deep. Pelvic fins relatively large, arising about midway between the pectorals and the anal; dorsal fin arising at the middle of the back, of moderate size, its maximum depth much less than that of the trunk at its point of origin; anal fin small.

Scales of moderate size, the exposed area rhombic in shape, ornamented with numerous closely arranged elongated tubercles, in horizontally directed parallel series.

Form. & Loc. Upper Hawkesbury-Wianamatta Series: Talbralgar, New South Wales.

Not represented in the Collection.

Genus **HOLURUS,** Traquair.

[Trans. Roy. Soc. Edinb. vol. xxx. 1881, p. 43.]

Trunk robust. Mandibular suspensorium oblique; teeth small and conical. Fin-rays simple, not branching, but merely attenuated distally; fulcra minute or absent. Dorsal fin rounded, elongated, arising in advance of the somewhat shorter anal; caudal fin obliquely truncated posteriorly, not forked. Scales sculptured; a prominent series of ridge-scales between the occiput and the dorsal fin.

Holurus parki, Traquair.

1881. *Holurus parki*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 44, pl. iii. figs. 9–12.

Type. Imperfect fish; Geological Survey of Scotland.

The type species, attaining a maximum length of about 0·1. Maximum depth of trunk contained about three and a half times in the total length. Head and opercular apparatus occupying about one quarter of the total length; external bones ornamented with fine striæ, sometimes interrupted. Scales of the abdominal region and the anterior portion of the caudal region finely striated, a few of the striæ concentric with the margins, but the majority oblique and some terminating in denticulations of the hinder border; ridge-scales finely striated.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4055. Imperfect head and abdominal region.
Purchased, 1883.

P. 5982. Imperfect fish, wanting part of the head and upper caudal lobe. *Purchased*, 1889.

Two doubtful species from the Calciferous Sandstones are also named *Holurus fulcratus* (Traquair, *loc. cit.* p. 46, pl. iii. figs. 13, 14) and *H. ischypterus* (*ibid.* p. 66, pl. iii. figs. 15, 16), the former from Eskdale and the latter from Coldstream Bridge. The first is

now re-named *Styracopterus fulcratus*, without definition (R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 492).

Generically indeterminable remains, probably of Palæoniscidæ, are also named thus:—

Turseodus acutus, J. Leidy, Proc. Acad. Nat. Sci. Philad. 1857, p. 167.—Triassic (?); Phœnixville, Chester Co., Pa. [Jaw; Academy of Sciences, Philadelphia.]

Urosthenes australis, J. D. Dana, Amer. Journ. Sci. [2] vol. v. (1848), p. 433.—Hawkesbury Series; New South Wales. [Tail; accidentally destroyed by fire.]

Isodus leptognathus, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 3.—Lower Carboniferous; Moyheeland, Draperstown, Ireland. [Dentary bone; Dublin Museum.]

Family PLATYSOMATIDÆ.

Trunk deeply fusiform or irregularly rhombic; tail heterocercal; scales rhombic, ganoid, firmly united with peg-and-socket articulations. Head-bones well developed, ganoid; no median series of cranial roof-bones; eye far forwards and high in position; snout prominent; mandibular suspensorium nearly vertical, slightly inclined downwards and forwards in the more specialized genera. A series of broad branchiostegal rays, with a small anterior azygous element at the symphysis of the mandible. Dorsal fin single, much extended.

As remarked in an elaborate memoir by Traquair[1], the osteology of the genera of this family, so far as known, is identical with that of the genera of Palæoniscidæ, the only essential difference being that in the present case specialization results in the extreme deepening of the head and trunk, whereas in the last-mentioned family the result is remarkable elongation of the whole body and the widening of the gape of the mouth. The typical Platysomatidæ have short, stout jaws, with a chiefly tritoral dentition; while the Palæoniscidæ are chiefly rapacious fishes, with conical laniaries.

It is also worthy of note that in the only typical genus in which the endoskeleton of the trunk has been clearly observed (*Platysomus*), the double series of robust dorsal fin-supports extends far in advance of the origin of the fin itself. The same arrangement is distinctly exhibited in the problematical Permian fish, *Dorypterus*,

[1] R. H. Traquair, "On the Structure and Affinities of the Platysomidæ," Trans. Roy. Soc. Edinb. vol. xxix. (1879), pp. 343–391, pls. iii.–vi.

which is here regarded as a highly specialized ally of the family destitute of squamation on the flanks.

Synopsis of Genera.

Trunk deeply fusiform; paired fins large; scales much imbricated; teeth rounded, tritoral..	*Eurynotus* (p. 528).
Trunk very deeply fusiform; paired fins well developed; scales slightly imbricated; teeth styliform, but tumid	*Mesolepis* (p. 531).
As *Mesolepis*, but teeth rounded, tritoral, in part pedunculated	*Globulodus* (p. 534).
Trunk very deeply fusiform; scales much imbricated; dorsal and anal fins relatively short and small	*Wardichthys* (p. 535).
Trunk rhombic; pectoral fins insignificant, pelvic fins absent; scales very deep and slightly imbricated; margin of mouth toothless, pterygoid and splenial with two denticulated longitudinal ridges	*Cheirodus* (p. 535).
As *Cheirodus*, but trunk very deeply fusiform and rounded, and pelvic fins present	*Cheirodopsis* (p. 540).
Trunk rhombic or very deep and rounded; paired fins small; scales very deep, slightly imbricated; marginal teeth feeble, styliform, those within tubercular	*Platysomus* (p. 541).

Genus **EURYNOTUS,** Agassiz.

[Poiss. Foss. vol. ii. pt. i, 1835, p. 153.]

Syn. *Plectrolepis*, L. Agassiz, *ibid.* 1844, p. 306 (name only).

Trunk deeply fusiform, the dorsal contour more or less angulated at the origin of the dorsal fin. Frontal profile of head sharply angulated immediately in advance of the orbit; head and opercular bones externally striated; teeth rounded and obtuse, closely arranged in irregular series on the splenial, dentary, maxilla, and bones of the roof of the mouth. Fin-rays closely articulated and distally bifurcating; fulcra present on all the fins. Pectoral fins relatively large and acutely pointed; pelvic fins well developed. Dorsal fin very long, extending from a point in advance of the middle of the trunk to the base of the caudal pedicle, high and acuminate in front, low and fringe-like behind; anal fin acuminate, with short base-line, opposite the hinder part of the dorsal; caudal fin deeply cleft, inequilobate. Scales smooth or feebly ornamented, usually with serrated hinder border, and having a broad overlapped

anterior border; principal flank-scales much deeper than broad, with large peg-and-socket articulation; dorsal and ventral scales somewhat broader than deep, with well-defined inner keel, but no peg-and-socket; scales of upper caudal lobe acutely lozenge-shaped. Well-developed ridge-scales present only upon the caudal pedicle and upper caudal lobe.

Eurynotus crenatus, Agassiz.

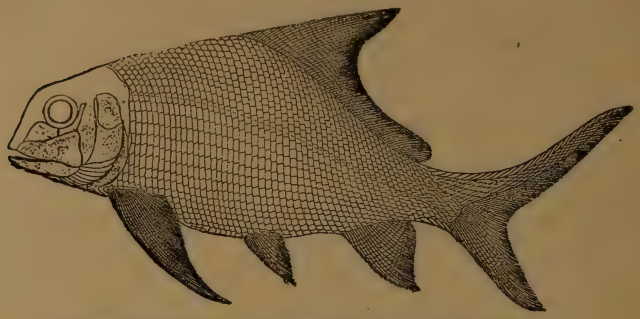
1835. *Eurynotus crenatus,* L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 154, pls. xiv. *a, b.*
1835. *Eurynotus fimbriatus,* L. Agassiz, *ibid.* p. 157, pl. xiv. *c.* figs. 1–3. [Portions of trunk; Oxford Museum.]
1835. *Eurynotus crenatus,* S. Hibbert, Trans. Roy. Soc. Edinb. vol. xiii. pl. vii. fig. 4.
1844. *Plectrolepis rugosus,* L. Agassiz, *tom. cit.* p. 306 (name only).
1850. *Plectrolepis rugosus,* Sir P. Egerton, Quart. Journ. Geol. Soc. vol. vi. p. 4. [British Museum.]
1854. *Platysomus declivus,* J. Morris (*ex* Agassiz, MS.), Cat. Brit. Foss. ed. 2, p. 339 (name only). [Distorted fish; British Museum.]
1867. *Eurynotus fimbriatus,* R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxiv. p. 710, pl. xlv. figs. 8, 9.
1879. *Eurynotus crenatus,* R. H. Traquair, *ibid.* vol. xxix. p. 349, pl. iii. figs. 1–16.
1881. *Eurynotus crenatus,* R. H. Traquair, *ibid.* vol. xxx. p. 54.
1890. *Eurynotus crenatus,* R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. pp. 392, 400.

Type. Imperfect fishes; Edinburgh Museum (in part).

The type species, attaining a length of about 0·25–0·3. Maximum depth of trunk equalling about one-third of the total length; the dorsal contour angulated at the origin of the dorsal fin, the ventral contour gently arched. Head and opercular apparatus small, occupying scarcely more than one-sixth of the total length; external bones ornamented with coarse striæ, often concentric; maxilla elongated, irregularly triangular, somewhat more than twice as deep behind as in front, the majority of its superficial striations vertical. Fin-rays and fulcra robust and smooth, the rays of the dorsal sometimes serrated posteriorly; pectoral fins more than twice as large as the pelvic pair, as deep as the anterior portion of the dorsal; anal fin deeper than long, terminating opposite the hinder extremity of the dorsal. Scales of moderate size, those of the anterior portion ornamented with delicate oblique striæ terminating in the posterior serrations, the striæ becoming obsolete towards the caudal region.

Form. & Loc. Calciferous Sandstones and Carboniferous Limestone Series: Midlothian, Fifeshire, and (?) Dumfriesshire.

Fig. 56.



Eurynotus crenatus, Ag.—Restoration by R. H. Traquair.

36044. Small crushed specimen wanting pectoral fins; Calciferous Sandstone, Burdiehouse, near Edinburgh.
Purchased, 1861.

50092. Imperfect trunk, with fragments of the head and fins, in counterpart; Burdiehouse. *Purchased*, 1879.

P. 976–7. Caudal region, labelled by Agassiz, and a fish about 0·2 in length wanting the upper part of the head and abdominal region and portions of the fins; Burdiehouse.
Egerton Coll.

P. 3504. Two small imperfect specimens and a small caudal region; Burdiehouse. *Enniskillen Coll.*

P. 5985. Remains of large head and abdominal region; Calciferous Sandstone, Wardie, near Edinburgh. *Purchased*, 1889.

P. 3507. Imperfect large trunk, with pelvic and median fins; probably from the Calciferous Sandstone of Cornceres, Fifeshire. *Enniskillen Coll.*

42077. Four imperfect small specimens, one being in counterpart; Calciferous Sandstone, Anstruther, Fifeshire.
Purchased, 1870.

42078. Four small specimens, vertically crushed; Anstruther.
Purchased, 1870.

42079–80. Two detached maxillæ; Anstruther. *Purchased*, 1870.

P. 3505. Large crushed fish, in counterpart, wanting the greater portion of the head and fins, but with well-preserved scales; Carboniferous Limestone (Edge-Coal Series), Wallyford, near Edinburgh. *Enniskillen Coll.*

P. 977 a. Type specimen of *Platysomus declivus*, Agassiz, being an imperfect small trunk wanting the tail and the greater part of the head: Calciferous Sandstone, Burntisland, Fifeshire. *Egerton Coll.*

P. 3506. Imperfect trunk, in counterpart; Carboniferous Limestone, Gilmerton, near Edinburgh. *Enniskillen Coll.*

P. 4620. Remains of fish showing pectoral fin; probably from the Carboniferous Limestone Series near Edinburgh. *Enniskillen Coll.*

P. 3478. Type specimen of *Plectrolepis rugosa*, Agassiz, as determined by Egerton. *Enniskillen Coll.*

The following species have also been named, but there are no examples in the Collection:—

Eurynotus (?) *aprion*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. (1881), p. 54, pl. v. fig. 20.—Calciferous Sandstone (Cement-stone Group); Tweeden Burn, Dumfriesshire. Lower Carboniferous; Moyheeland, Ireland. [Scales; Geological Survey of Scotland.]

Eurynotus insignis, R. H. Traquair, *ibid.* vol. xxix. (1879), p. 349: *Platysomus* (?) *insignis*, L. G. de Koninck, Faune Calc. Carb. Belg. pt. i. (1878), p. 25, pl. iii. figs. 1, 2.—Carboniferous Limestone; Viesville, Belgium. [Imperfect head and abdominal region; Royal Museum, Brussels.]

Eurynotus microlepidotus, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. (1890), p. 400.—Middle Carboniferous Limestone; Loanhead, near Edinburgh. [Collection of Dr. R. H. Traquair.]

The so-called *Eurynotus tenuiceps*, Ag., is a species of *Semionotus* (see Part III.).

Genus **MESOLEPIS**, Young.

[Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 313.]

Syn. *Pododus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. 1844, p. 83 (name only).

Trunk very deeply fusiform, the dorsal contour more or less angulated at the origin of the dorsal fin. Frontal profile of head sharply angulated immediately in advance of the orbit; head and opercular

bones ornamented with striæ and granulations; teeth robust, styliform, often constricted and somewhat tumid in the upper half, arranged in single series in the lower jaw. Fin-rays closely articulated and distally bifurcating; fulcra present on all the fins. Pectoral fins of moderate size; pelvic fins well developed. Dorsal fin very long, extending at least from the middle point of the trunk to the base of the caudal pedicle, high and acuminate in front, low and fringe-like behind; anal fin similarly shaped, but extending only opposite the hinder half of the dorsal; caudal fin deeply cleft, inequilobate. Scales ornamented with tuberculations or short sinuous striæ, with smooth hinder border and very narrow overlapped anterior border; principal flank-scales much deeper than broad, with an anterior inner keel and large peg-and-socket articulation; dorsal and ventral scales, and those of the caudal pedicle, at least as broad as deep, with mesially placed peg-and-socket and feeble inner keel; scales of upper caudal lobe acutely lozenge-shaped. Well-developed ridge-scales present only upon the upper caudal lobe.

Mesolepis wardi, Young.

(?) 1844. *Pododus capitatus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 163 (name only).

1866. *Mesolepis wardi*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 313, pl. xxi. figs. 1, 3.

1875. *Mesolepis wardi*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 234.

1890. *Mesolepis wardi*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 181.

Type. Fish wanting the pectoral and dorsal fins and part of the head; collection of John Ward, Esq., Longton.

The type species, attaining a maximum length of about 0·15. "Body ovate; the posterior dorsal slope more rapid than that of the anal region. Length of trunk, from pectoral to tail-root, nearly twice its greatest depth. Caudal pedicle thick, elongate." Teeth of lower jaw tumid distally. "Scales ornamented with tubercles, more or less confluent into approximately vertical ridges." (*Young.*)

Form. & Loc. Coal-Measures: North Staffordshire and (?) Yorkshire and Lanarkshire.

P. 1609. Imperfect caudal and hinder abdominal region, wanting the median fins, except a portion of the lower lobe of the caudal, but displaying the pelvic fins with their ornamented rays; Knowles Ironstone Shale, Fenton. *Egerton Coll.*

P. 1604. Two small groups of scales, doubtfully referable to this species, one specimen being labelled *Platysomus parvulus* by Agassiz; Leeds. *Egerton Coll.*

Mesolepis scalaris, Young.

1866. *Mesolepis scalaris*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 313.
1875. *Mesolepis scalaris*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 235.
1879. *Mesolepis scalaris*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. p. 355, pl. iv. figs. 1–5.
1890. *Mesolepis scalaris*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 182, pl. vii. figs. 10–14.

Type. Fish; collection of John Ward, Esq., Longton.

Dorsal contour of trunk strongly arched, the maximum depth, at the origin of the dorsal fin, nearly equal to the length of the trunk from the pectoral arch to the base of the caudal fin; caudal pedicle short and narrow. Head and opercular apparatus occupying about one-third of the length to the base of the caudal fin; teeth of lower jaw tumid distally. Pelvic fins arising midway between the pectorals and the anal; dorsal fin very high in front, its maximum height contained two and a half times in the depth of the trunk at its origin; caudal fin very large and deeply cleft. Tuberculations of scale-ornament confluent into short, fine, vermiculating ridges.

Form. & Loc. Coal-Measures: North Staffordshire.

Not represented in the Collection.

The following specimen is of undetermined species. In some respects it is suggestive of *M. rhomba*; but although very coarsely rugose, the scales are at least as broad and large as in the type species.

P. 4084. Fragmentary remains of the head and trunk, about 0·105 in length, exhibiting regular coarse striations on the opercular bones, and an irregular rugosity of angularly bent ridges on the scales; Calciferous Sandstone, Eskdale. *Purchased*, 1883.

The following species have also been briefly described, but do not appear to be represented in the Collection:—

Mesolepis microptera, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. (1879), p. 356, pl. iv. fig. 8.—Lower Coal-Measures (Dalemoor Rake Ironstone); Stanton-by-Dale, Derbyshire. [Imperfect fish; E. W. Binney Collection.]

Mesolepis rhomba, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. (1890) p. 493.—Calciferous Sandstones (Cementstone Group); Eskdale, Dumfriesshire. [Imperfect fish; Edinburgh Museum.]

Mesolepis tuberculata, R. H. Traquair, *ibid.* p. 493.—Ibid. [Ditto.]

Genus **GLOBULODUS,** Münster.

[Beitr. Petrefakt. pt. v. 1842, p. 47.]

Syn. *Eurysomus,* J. Young, Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 311.

Form and proportions of trunk, fins, and squamation as in *Mesolepis.* A single series of large, rounded, and flattened pedunculated teeth on the margin of the upper and lower jaws, and smaller tritoral teeth within.

Globulodus macrurus (Agassiz).

1829. "Fossil Fish," A. Sedgwick, Trans. Geol. Soc. [2] vol. iii. p. 118, pl. xii. figs. 1, 2.
1835. *Platysomus macrurus,* L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 6, 95, 170, pl. xviii. figs. 1, 2 (includes *Uropteryx undulatus,* Ag. MS.).
1842. *Platysomus fuldai,* G. von Münster, Beitr. Petrefakt. pt. v. p. 45, pl. vi. fig. 1. [Palæontological Museum, Munich.]
1842. *Globulodus elegans,* G. von Münster, *ibid.* p. 47, pl. xv. fig. 7. [Jaw; Palæontological Museum, Munich.]
1849. *Platysomus macrurus,* Sir P. Egerton, Quart. Journ. Geol. Soc. vol. v. p. 329, woodc. fig. 1.
1850. *Platysomus macrurus,* Sir P. Egerton, in King's Permian Foss. (Palæont. Soc.), p. 227, pl. xxvi. fig. 1.
1861. *Platysomus macrurus,* H. B. Geinitz, Dyas, p. 10, pl. iv. fig. 2.
1866. *Eurysomus macrurus,* J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 311.
1879. *Eurysomus macrurus,* R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. p. 359, pl. iv. figs. 10, 11.
1889. *Globulodus macrurus,* R. Howse, Guide Coll. Local Foss. Mus. Nat. Hist. Soc., Newcastle-upon-Tyne, p. 24.

Type. Imperfect fish; unknown.

The type species, attaining a maximum length of not less than 0·35. Greatest depth of trunk slightly less than its length from the pectoral arch to the base of the caudal fin; caudal pedicle very robust, nearly one quarter as deep as the trunk. Dorsal and anal fins deep and robust, the latter two-thirds as long as the former; caudal fin very robust and widely spread, its depth at least equalling that of the trunk; fin-rays ornamented with transverse striations. Scales coarsely striated.

Form. & Loc. Upper Permian (Kupferschiefer): Germany. Upper Permian (Marl Slate): Durham.

P. 3495. Fragmentary remains of head and trunk; Marl Slate, Midderidge. *Enniskillen Coll.*

Genus **WARDICHTHYS**, Traquair.

[Ann. Mag. Nat. Hist. [4] vol. xv. 1875, p. 266.]

Trunk very deep, nearly circular in side view. [Dentition unknown.] Fin-rays closely articulated and distally bifurcating; fulcra present. [Paired fins unknown.] Dorsal fin small, arising considerably behind the middle point of the back, high and acuminate in front, fringe-like behind; anal fin similarly shaped, but still smaller, and both these fins terminating at the base of the caudal pedicle; [caudal fin unknown]. Scales ornamented with tuberculations or short striæ, with smooth hinder border and broad overlapped anterior border; principal flank-scales much deeper than broad, with an anterior inner keel and broad peg-and-socket articulation; dorsal and ventral scales, and those of the caudal pedicle, at least as broad as deep. Well-developed, acuminate ridge-scales present in advance of the dorsal and anal fins.

Wardichthys cyclosoma, Traquair.

1875. *Wardichthys cyclosoma*, R. H. Traquair, Ann. Mag. Nat. Hist. [4] vol. xv. p. 262, pl. xvi. figs. 1–5.
1879. *Wardichthys cyclosoma*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. p. 361, pl. iv. figs. 12–15.
1881. *Wardichthys cyclosoma*, T. Stock, Ann. Mag. Nat. Hist. [5] vol. vii. p. 490.

Type. Fish, wanting tail and paired fins; collection of Dr. R. H. Traquair.

The type species, attaining a length of about 0·09. Tuberculations of scales very coarse, tending towards fusion into transverse ridges.

Form. & Loc. Calciferous Sandstones: Wardie, near Edinburgh.

46812. Plaster cast of type specimen.

Presented by Dr. R. H. Traquair, 1875.

Genus **CHEIRODUS**, M'Coy.

[Ann. Mag. Nat. Hist. [2] vol. ii. 1848, p. 130 (*Chirodus*).]

Syn. *Amphicentrum*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 306.
Hemicladodus, J. W. Davis, Quart. Journ. Geol. Soc. vol. xl. 1884, p. 620.

Trunk deep and rhombic, the dorsal and ventral margins elevated into peaks, which are nearly or quite opposite. Upper contour of

head continuing the downward slope of the back in front of the peak, with a slight convexity above and in advance of the orbit, below which the facial profile is more abrupt; margins of maxilla, premaxilla, and dentary toothless; inner surface of maxilla and pterygoid with cluster of small tubercular teeth; oral aspect of pterygoid and splenial bones with two sharp longitudinal ridges, meeting posteriorly, and more or less coarsely denticulated. Fin-rays closely articulated and distally bifurcating; fulcra present on all the fins. Pectoral fins small and delicate, laterally placed; [pelvic fins unknown]. Dorsal and anal fins of nearly equal size and shape, arising behind the dorsal and ventral peaks and terminating at the base of the caudal pedicle, high and acuminate in front, low and fringe-like in the posterior two-thirds; caudal fin deeply cleft, nearly equilobate. Scales ornamented with tuberculations and striæ, with smooth hinder border, and narrow overlapped anterior border; principal flank-scales very deep and narrow, with large anterior inner keel, and a large, broad, peg-and-socket articulation extending nearly the entire width of the scale; scales dorsally and ventrally and towards the caudal pedicle less deep in proportion to their breadth; scales of upper caudal lobe relatively small and lozenge-shaped. Well-developed ridge-scales present only upon the upper caudal lobe.

The type species of this genus is known only by a detached splenial bone, which is insufficient for precise diagnosis. It is described as follows:—

Cheirodus pes-ranæ, F. M'Coy, Ann. Mag. Nat. Hist. [2] vol. ii. (1848), p. 131, and Brit. Palæoz. Foss. (1855), p. 616, pl. iii. G. fig. 9; R. H. Traquair, Ann. Mag. Nat. Hist. [5] vol. ii. (1878), p. 17; J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. (1883), p. 523, pl. lxiii. fig. 5.—Upper Carboniferous Limestone; Derbyshire. [Woodwardian Museum, Cambridge.]

Cheirodus granulosus (Young).

1866. *Amphicentrum granulosum*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 306, pl. xx.

1875. *Amphicentrum granulosum*, R. H. Traquair, Ann. Mag. Nat. Hist. [4] vol. xvi. p. 273, pl. ix.

1875. *Amphicentrum granulosum*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 236.

1878. *Cheirodus granulosus*, R. H. Traquair, Ann. Mag. Nat. Hist. [5] vol. ii. p. 17.

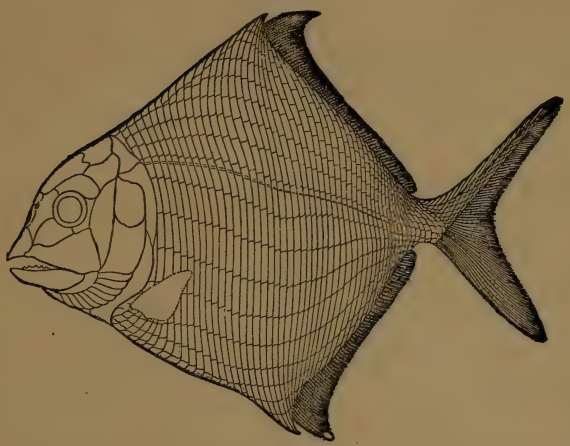
1879. *Cheirodus granulosus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. p. 363, pl. v.

1890. *Cheirodus granulosus*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 184, pl. vii. figs. 1–9.

Type. Well-preserved fish; collection of John Ward, Esq., Longton.

A species attaining a maximum length of about 0·2. Dorsal and ventral peaks of trunk acuminate, reflexed, the former very slightly in advance of the latter, and the distance between the two about equal to the total length of the head and trunk without the caudal fin. Head and opercular apparatus occupying nearly one quarter

Fig. 57.



Cheirodus granulosus (Young).—Restoration by R. H. Traquair.

of the total length; both ridges of pterygoid and splenial bones coarsely, but irregularly denticulated. Dorsal and anal fins arising immediately behind the dorsal and ventral peaks, forming an insignificant low fringe; depth of caudal expansion considerably more than one-half the maximum depth of the trunk. Scale-ornament, as also that of the head and opercular bones and pectoral arch, consisting of coarse tuberculations, sometimes partly confluent, often arranged in series.

This is the type species of the so-called *Amphicentrum*.

Form. & Loc. Coal-Measures: Staffordshire, Lancashire, and Lanarkshire.

P. 235. Very large specimen, somewhat crushed, wanting the head and tail; Knowles Ironstone, Longton, North Staffordshire. Many of the scales, the dorsal peak, and portions of the dorsal and anal fins are well shown. *Weaver-Jones Coll.*

P. 5184. Equally large specimen in similar matrix, showing the lower lobe and part of the upper lobe of the caudal fin; Longton. *Purchased*, 1885.

P. 1608. Another large specimen in similar matrix, wanting the tail, all the fins except the anterior portion of the dorsal, and the extremity of the snout; Longton. The fish is chiefly shown as an impression in the matrix, displaying the opercular apparatus, and a portion of the clavicle behind, in addition to the well-preserved squamation. *Egerton Coll.*

P. 1608 a. Smaller imperfectly preserved specimen, showing the anterior portion of the dorsal fin and part of the upper caudal lobe; Deep-mine Ironstone Shale, Longton. *Egerton Coll.*

P. 1608 b. Very small individual, wanting the greater portion of the head, and with imperfect tail; Deep-mine Ironstone Shale, Longton. *Egerton Coll.*

P. 1610. Remains of head and abdominal region of a small individual; Knowles Ironstone Shale, Fenton, North Staffordshire. The characters of the squamation are well exhibited, and in the head the maxilla, pterygoid, and other elements are more or less incompletely preserved. *Egerton Coll.*

P. 1610 a. Very small fish; Deep-mine Ironstone Shale, Longton. *Egerton Coll.*

P. 3502. Four small imperfect specimens in similar matrix; Fenton. *Enniskillen Coll.*

P. 3502 a. Fine head and trunk wanting the tail; Knowles Ironstone Shale, Fenton. Portions of the maxilla, premaxilla, pterygoid, splenial, and dentary are displayed in the head; and there are impressions of the opercular apparatus, the clavicle, and supraclavicle, posteriorly. The squamation is much fractured, but well shown. *Enniskillen Coll.*

P. 4617. Similar, but more imperfectly preserved specimen; Deep-mine Ironstone Shale, Longton. *Enniskillen Coll.*

P. 5185. Two imperfect specimens, wanting the tail; Hanley, North Staffordshire. One specimen shows part of a pectoral fin, and also the anterior portion of the dorsal fin, which is higher and more acuminate than is shown in Traquair's restoration. *Purchased*, 1885.

P. 5184 a, b, P. 5187. Three imperfect examples of the head and trunk, of moderate size, the third showing portions of the dorsal fin; Deep-mine Ironstone Shale, Longton. *Purchased*, 1885.

P. 5186. Small imperfect specimen, in counterpart; Longton. *Purchased*, 1885.

P. 4617 a. Imperfect head and anterior scales, showing the outer aspect of the left dentary bone and fragments of the dentition; Silverdale, North Staffordshire. *Enniskillen Coll.*

36893–94, 37381. Three specimens with remains of squamation and fragmentary head-bones, probably from Knowles Ironstone Shale, Fenton. *Purchased*, 1862–63.

36898. Two pterygoid (or splenial) bones, one being much abraded; Longton. *Purchased*, 1862.

P. 1611–2. Four similar bones; Longton. *Egerton Coll.*

P. 3503. Five similar bones; Fenton. *Enniskillen Coll.*

P. 1613. Right maxilla, inner aspect, showing the band of tubercular teeth; Longton. *Egerton Coll.*

46027. Scales and fragments of head-bones of a large fish, coarsely ornamented, doubtfully of this species; Airdrie, Lanarkshire. *Purchased*, 1874.

P. 4087. Imperfect fish, wanting all the fins except a portion of the caudal; Brown Mine Ironstone, Apedale, North Staffordshire. *Purchased*, 1883.

Cheirodus striatus (Hancock & Atthey).

1872. *Amphicentrum striatum*, Hancock & Atthey, Ann. Mag. Nat. Hist. [4] vol. ix. p. 255 (reprinted in Nat. Hist. Trans. Northumb. & Durham, vol. iv. p. 414).

1879. *Cheirodus striatus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. p. 364.

Type. Imperfect fish; Newcastle-upon-Tyne Museum.

A very small species, with the trunk much deeper than long. Dorsal and ventral scales granulated, those of the middle of the flank having the tubercles fused into delicate vertical striations.

Form. & Loc. Coal-Measures: Northumberland.

41631. Small pterygoid bone; Newsham, near Newcastle-upon-Tyne. *Presented by T. P. Barkas, Esq.*, 1869.

P. 4796. Similar but smaller bone; Newsham.
Presented by Sir Richard Owen, K.C.B., 1884.

The pterygoid or splenial bone of an undetermined species of *Cheirodus* has also been recorded from the Upper Carboniferous Limestone of Richmond, Yorkshire, by W. J. Barkas, Geol. Mag. [2] vol. i. (1874), p. 431; and a similar fossil from the Yoredale Rocks of Wensleydale, Yorkshire, now in the York Museum, is the type of the genus and species, *Hemicladodus unicuspidatus*, J. W. Davis, Quart. Journ. Geol. Soc. vol. xl. (1884), p. 620, pl. xxvii. fig. 24.

A tooth from the Coal-Measures of Ohio is briefly noticed under the name of *Cheirodus acutus*, J. S. Newberry, Proc. Acad. Nat. Sci. Philad. vol. viii. (1856), p. 99.

Scales from the Carboniferous Limestone of Abden, Fifeshire, now in the Edinburgh Museum, are also noticed under the name of *Cheirodus crassus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. (1890), p. 400. Similar scales are recorded from Beith, Ayrshire.

Genus **CHEIRODOPSIS,** Traquair.

[Trans. Roy. Soc. Edinb. vol. xxx. 1881, p. 56.]

Trunk deep, the dorsal and ventral margins gently convex. Head and dentition as in *Cheirodus*. Pectoral and pelvic fins small. Rays of median fins with distant articulations and distally bifurcating; fulcra present. Dorsal fin arising considerably behind the middle point of the back, high and acuminate in front, elongated; anal fin similar, but smaller, opposed to the hinder portion of the dorsal; caudal fin cleft. Scales very deep and narrow, with relatively broad overlapped anterior border, and the exposed portion ornamented with a coarse "tuberculo-corrugate" pattern, which passes into prominent serrations at the hinder border; anterior inner keel thick, and peg-and-socket articulation well developed.

Cheirodopsis geikiei, Traquair.

1881. *Cheirodopsis geikiei,* R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 56, pl. v. figs. 17–19.

1890. *Cheirodopsis geikiei,* R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. p. 494.

Type. Imperfect fish, wanting paired and caudal fins; Geol. Survey of Scotland, Edinburgh.

The type species, of small size. Head relatively large, it with the opercular apparatus probably measuring more than one quarter of the total length of the fish; external bones ornamented with coarse, tortuous, and reticulating corrugations. Scales with an especially coarse ornament.

This species cannot be satisfactorily defined until the discovery of more completely preserved specimens.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4056. Remains of two small fishes, one showing parts of the median fins. *Purchased*, 1883.

P. 4084. Imperfect large specimen, wanting the tail and the greater portion of the head, and with fragments only of the dorsal and anal fins. The length of the trunk from the pectoral arch to the end of the caudal pedicle must have been originally about 0·06. *Purchased*, 1883.

Genus **PLATYSOMUS,** Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1835, pp. 6, 161.]

Syn. *Uropteryx,* L. Agassiz, MS. in collections.

Trunk deep, more or less rhombic, the dorsal and ventral margin being angulated or sharply rounded. Facial contour of head steep, with no marked prominence above or in advance of the orbits; margins of jaws with minute styliform teeth, tubercular within. Fin-rays closely articulated and distally bifurcating; fulcra small or absent. Pectoral fins small, inferiorly placed; pelvic fins much smaller and remote. Dorsal fin arising about the middle point of the back, much elongated, high and acuminate in front, low and fringe-like in the posterior two-thirds; anal fin similar in form, somewhat shorter, but terminating at the same point posteriorly; caudal fin deeply cleft, nearly equilobate. Scales ornamented with more or less vertical striations, with smooth hinder border, and narrow overlapped anterior border; principal flank-scales very deep

and narrow, with large anterior inner keel, and a large, broad peg-and-socket articulation often extending nearly the entire width of the scale; scales dorsally and ventrally and towards the caudal pedicle less deep in proportion to their breadth; scales of upper caudal lobe lozenge-shaped. Ridge-scales in advance of dorsal and anal fins small, those of the upper caudal lobe very large.

Platysomus gibbosus (Blainville).

[Plate XV. fig. 5.]

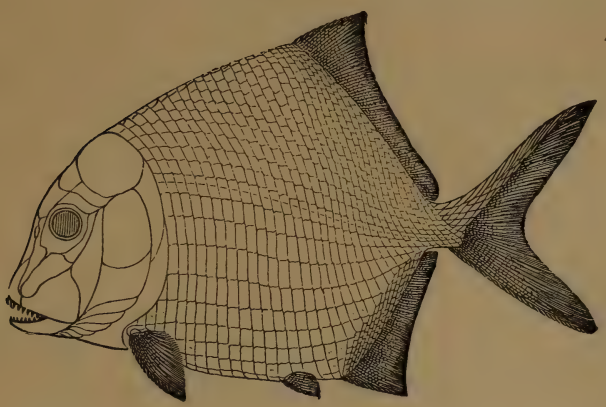
1708. *Rhombus diluvianus major et minor*, J. J. Scheuchzer, Piscium Querelæ et Vindiciæ, pl. iv.
1719. *Rhombus diluvianus minor*, P. Wolfart, Hist. Nat. Hassiæ inf. pl. xiii., pl. xiv. fig. 1.
1815. "Flat Fish," W. R. Clanny, Annals of Philosophy, vol. vi. p. 115, with plate.
1817. "Fish (? *Chætodon*)," N. J. Winch, Trans. Geol. Soc. vol. iv. p. 9, pl. ii.
1818. *Stromateus gibbosus*, H. D. de Blainville, Nouv. Dict. d'Hist. Nat. vol. xxvii. p. 322.
1818. *Stromateus major*, H. D. de Blainville, *ibid.* p. 322.
1824. *Stromateus knorrii*, E. F. Germar, Leonhard's Mineral. Taschenbuch, p. 70, pl. ii.
1824. *Stromateus angulatus*, E. F. Germar, *ibid.* p. 71, pl. iii. fig. 2.
1829. "Fossil Fish," A. Sedgwick, Trans. Geol. Soc. [2] vol. iii. pl. xii. figs. 3, 4.
1833–35. *Platysomus gibbosus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. pp. 6, 164, pl. xv.
1833–35. *Platysomus rhombus*, L. Agassiz, *ibid.* pp. 6, 167, pl. xvi. [Paris Museum of Natural History.]
1833–35. *Platysomus striatus*, L. Agassiz, *ibid.* pp. 6, 168, pl. xvii. figs. 1–4 (includes *Uropteryx striatus*, Ag. MS.). [Museum of Newcastle-upon-Tyne.]
1833–35. *Platysomus parvus*, L. Agassiz, *ibid.* pp. 6, 170, pl. xviii. fig. 3.
1839. *Platysomus gibbosus*, G. A. Kurtze, Comment. Petrefact. Mansfeld. p. 22.
1839. *Platysomus rhombus*, G. A. Kurtze, *ibid.* p. 24.
1840. *Platysomus gibbosus*, E. F. Germar, Verstein. Mansfeld. Kupferschief. p. 25.
1840. *Platysomus rhombus*, E. F. Germar, *ibid.* p, 26.
1842. *Platysomus intermedius*, G. von Münster, Beitr. Petrefakt. pt. v. p. 43. [Palæontological Museum, Munich.]
1850. *Platysomus striatus*, W. King, Permian Foss. (Palæont. Soc.), p. 231, pl. xxvii. fig. 1, pl. xxviii. fig. 1.
1855. *Platysomus striatus*, F. M'Coy, Brit. Palæoz. Foss. p. 614.
1861. *Platysomus gibbosus*, H. B. Geinitz, Dyas, p. 8, pl. vi. figs. 1–3.
1861. *Platysomus intermedius*, H. B. Geinitz, *ibid.* p. 9.

1861. *Platysomus rhombus*, H. B. Geinitz, *ibid.* p. 9.
1861. *Platysomus striatus*, H. B. Geinitz, *ibid.* p. 9.
1879. *Platysomus striatus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. p. 369, pl. vi. figs. 1, 2.

Type. Fish; Paris Museum of Natural History.

The type species, attaining a maximum length of about 0·35. Greatest depth of trunk somewhat exceeding its length from the pectoral arch to the base of the caudal fin; dorsal margin angulated about its middle point; ventral margin angulated considerably behind its middle point. Length of cranial roof with post-temporal bone about equal to the distance between the latter and the dorsal angulation; head with opercular apparatus and pectoral arch occupying about one-third of the total length of the fish to the base of the caudal fin. Pelvic fins very small, remote; dorsal and anal fins arising at the dorsal and ventral angulations respectively, ex-

Fig. 58.



Platysomus gibbosus (Blainv.).—Restoration by R. H. Traquair.

tending close to the origin of the caudal fin, and not much elevated in front, the maximum height of the dorsal less than one quarter the depth of the trunk at its origin; width of caudal fin at extremity equalling about two-thirds the maximum depth of the trunk. Scales finely striated, the striæ being oblique on all those situated dorsally and ventrally and in the caudal region, but nearly vertical on the deeper flank-scales; the ornament on the scales of the dorsal and ventral borders more or less tuberculated. Vertical series of scales at base of anal fin reflexed forwards.

Measurements of several specimens show that there is no difference

in the relative proportions of the head between the Kupferschiefer fossils and those named *striatus* from the English Marl Slate; and in all these fishes the scale-ornament is identical. The rounded form of the dorsal and ventral margins in the so-called *P. rhombus* is due to accident in preservation, the median fins being almost or completely destroyed in fishes exhibiting this contour.

Form. & Loc. Upper Permian (Kupferschiefer): Germany. Upper Permian (Lower Magnesian Limestone and Marl Slate): Durham and Northumberland.

(i.) *Kupferschiefer.*

44864. Fish of moderate size, in counterpart, wanting the ventral border of the abdominal region and the greater part of the dorsal and anal fins: Mansfeld, Thuringia. Parts of the endoskeleton of the trunk are well shown, the distal series of short baseosts in the anal fin being conspicuous, and the proximal series of dorsal fin-supports (axonosts) extending forwards as far as the occiput.

Presented by Benjamin Bright, Esq., 1873.

35530. Small fish, 0·145 in length, nearly complete, but wanting the pelvic fins; Riechelsdorf, Hesse. *Purchased*, 1859.

43431. Imperfect small specimen, wanting the lower jaw and fins; Riechelsdorf. The form of the cranium, lateral aspect, is well shown, and there is a series of styliform teeth in the upper jaw.

Presented by Kenneth Murchison, Esq., 1872.

43430. More imperfect larger specimen; Riechelsdorf.

Presented by Kenneth Murchison, Esq., 1872.

P. 1601. Fine small specimen, about 0·095 in length; Riechelsdorf. *Egerton Coll.*

P. 1599. Head and trunk, 0·16 in length, wanting caudal lobe and fin; Riechelsdorf. *Egerton Coll.*

P. 3496–7. Four imperfect specimens, one displaying the pectoral, pelvic, and dorsal fins, and another exhibiting one of the pectoral fins; Riechelsdorf. *Enniskillen Coll.*

18513. Large specimen displaying portions of the scale-ornament in impression; Eisleben, Saxony. *Purchased*, 1844.

28279. Large head and trunk, showing parts of the endoskeleton of the trunk, and the pelvic, dorsal, and anal fins; Eisleben. *Purchased*, 1853.

P. 1597, P. 4425. Imperfect head and trunk, without fins, in counterpart, Eisleben. *Egerton & Enniskillen Colls.*

P. 3492. Head and well-preserved portion of squamation, labelled by Agassiz; Eisleben. *Enniskillen Coll.*

P. 1598, P. 3493. Nodule with imperfect head and trunk, doubtfully of this species; Ilmenau, Thuringia. *Egerton & Enniskillen Colls.*

(ii.) *Marl Slate.*

39160, P. 556. Specimen of the so-called *P. striatus*, in counterpart, figured in King's 'Permian Fossils,' pl. xxvii.; Ferry Hill, Durham. Some of the robust styliform teeth are well shown in the upper jaw; and the tuberculated ornament of the scales at the dorsal and ventral borders of the abdominal region is also conspicuous. *Bowerbank & Egerton Colls.*

P. 3494. Similar specimen with more imperfect head, chiefly shown as an impression upon the matrix; Ferry Hill. *Enniskillen Coll.*

P. 3498. Small fish, 0·19 in length, with imperfect dorsal border, and wanting the dorsal and pelvic fins; Midderidge, Durham. *Enniskillen Coll.*

P. 3498 a. Smaller imperfect trunk, wanting the dorsal and paired fins; Midderidge. *Enniskillen Coll.*

P. 1607. Caudal region, labelled *Platysomus macrurus* by Egerton; Midderidge. *Egerton Coll.*

P. 1606. Portion of a very small trunk, showing the pelvic fins in position, with the imperfect anal fin, the hinder portion of the dorsal, and the base of the caudal; Midderidge. The specimen is represented, of the natural size, in Pl. XV. fig. 5. *Egerton Coll.*

The following species is founded upon an imperfect head and trunk, and is evidently closely allied to *P. gibbosus*:—

Platysomus biarmicus, E. von Eichwald, Bull. Soc. Imp. Nat. Moscou, vol. xxx. (1857), pt. ii. p. 348, and Leth. Rossica, vol. i. (1860), p. 1591, pl. lvi. fig. 7.—Permian; Kargala, Govt. of Orenburg, Russia. [University of Moscow.]

Platysomus forsteri, Hancock & Atthey.

1872. *Platysomus forsteri*, Hancock & Atthey, Ann. Mag. Nat. Hist. [4] vol. ix. p. 254, pl. xvii. fig. 3 (reprinted in Nat. Hist. Trans. Northumb. & Durham, vol. iv. p. 413, pl. xv. fig. 3).

1879. *Platysomus forsteri*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. p. 369, pl. vi. fig. 10.

Type. Imperfect fish; Newcastle-upon-Tyne Museum.

A species probably equalling the type in size; [form and proportions of head and trunk unknown]. Striations of scales fine, more or less undulating, usually somewhat oblique to the anterior border even in those of the flank, and tending to become abruptly intercalated; peg-and-socket articulation of principal scales relatively large and broad.

Form. & Loc. Coal-Measures: Yorkshire, Northumberland, and Lanarkshire.

P. 1185. Scattered remains of a typical fish; Middle Coal-Measures, Tingley, Yorkshire.
Presented by the Earl of Enniskillen, 1882.

P. 3500. Vertically crushed head and scales; Carluke, Lanarkshire.
Enniskillen Coll.

P. 3501. Group of scales; Carluke. *Enniskillen Coll.*

37322. Imperfect head and abdominal region, with pelvic fins, probably of this species; Airdrie, Lanarkshire.
Purchased, 1863.

Platysomus parvulus, Williamson.

1844. *Platysomus parvulus*, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 303 (name only).

1849. *Platysomus parvulus*, W. C. Williamson, Phil. Trans. p. 449, pl. xli. figs. 12–14.

1866. *Platysomus parvulus*, J. Young, Quart. Journ. Geol. Soc. vol. xxii. p. 303, pl. xxi. fig. 2.

1875. *Platysomus parvulus*, J. Ward, [Proc.] N. Staffs. Nat. Field Club, p. 235.

1879. *Platysomus parvulus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. p. 369, pl. vi. figs. 3–9, 11.

1890. *Platysomus parvulus*, J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. p. 180, pl. viii. figs. 1–4.

1890. *Platysomus parvulus*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. p. 392.

Type. Scales; unknown.

A small species attaining a maximum length of about 0·12. Greatest depth of trunk exceeding its length from the pectoral arch to the base of the caudal fin; dorsal margin much raised and angulated at a very short distance behind the head; ventral margin sharply bent, but rounded, immediately behind its middle point. Head relatively large, it with the opercular apparatus and pectoral arch occupying considerably more than one-third of the total length of the fish to the base of the caudal fin; most of the head-bones finely striated, but those of the cranial roof also in part granulated. Pelvic fins very small, remote; dorsal fin arising at a point about as far behind the dorsal peak as the distance of the latter from the occiput, terminating some distance in advance of the caudal fin; anal fin somewhat shorter than the dorsal, but terminating at the same point, and both these fins sharply acuminate in front; caudal pedicle long and slender, and the width of the caudal fin at the extremity equalling about half the maximum depth of the trunk; rays of median fins finely ornamented with oblique striæ. Scales finely striated, the striæ being parallel, even, and regular, vertical on the deeper flank-scales, but oblique on those situated dorsally, ventrally, and upon the caudal region; ridge-scales in advance of dorsal and anal fins with irregularly arranged, recurved denticles, those of the dorsal margin of the caudal lobe relatively large and granulated.

Form. & Loc. Coal-Measures: Staffordshire, Lancashire, Yorkshire, and Northumberland; Midlothian and Lanarkshire.

P. 237. Much crushed imperfect small specimen, displaying some of the asperities upon the ventral ridge-scales; Knowles Ironstone Shale, Fenton, North Staffordshire.

Weaver-Jones Coll.

P. 1602–3. Three more typical specimens of larger size; Fenton. One of the two specimens included under the first number shows the distant articulations of the pectoral fin-rays, and the numerous spines upon the dorsal and ventral ridge-scales; while both this and the third fossil exhibit the ornamentation of the median fin-rays. *Egerton Coll.*

P. 3499 a. A very small fish exhibiting the dorsal peak and the greater part of the caudal fin; also a much crushed larger specimen, wanting the median fins; Fenton. The latter specimen shows a series of mandibular teeth, and one of the pectoral fins with its sparsely jointed rays, which bifurcate distally: below the anal region of this fish there

is also a detached scale showing tuberculations near its ventral border. *Enniskillen Coll.*

P. 5198–9. Two fine specimens, the second measuring 0·11 in length; Longton, North Staffordshire. Both these fossils exhibit the form of the head and trunk, and part of the upper and lower dentition of the fish, besides the proportions of the pectoral and median fins. *Purchased*, 1885.

P. 5190. Four imperfect fishes; Longton. One is in counterpart, displaying the operculum, suboperculum, and post-temporal, with other bones; another exhibits well the scale-ornament; while a third also shows several head and opercular bones, in addition to the maxillary dentition. *Purchased*, 1885.

P. 5191. Very small imperfect fish, showing the dorsal peak; Longton. *Purchased*, 1885.

36892. Somewhat larger imperfect trunk with parts of the caudal fin; Longton. *Purchased*, 1862.

21975. Two much crushed and broken examples of the caudal region, in counterpart, probably of this species; Carluke, Lanarkshire. The fin-rays do not exhibit the characteristic ornament—a circumstance that may be due to their splitting and showing the inner face. *Purchased*, 1848.

P. 3500 a. Group of scales labelled by Agassiz; Carluke, Lanarkshire. *Enniskillen Coll.*

Platysomus tenuistriatus, Traquair.

1866. *Platysomus striatus*, J. Young (*errore*), Quart. Journ. Geol. Soc. vol. xxii. p. 305.

1879. *Platysomus tenuistriatus*, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. p. 369.

Type. Fish; Museum of Practical Geology.

A small species attaining a length of about 0·09. Body rounded; dorsal margin strongly and evenly arched from the occiput to the narrow caudal pedicle; ventral margin more gently curved from the branchial region to the origin of the anal fin, from which it then slopes rapidly upwards. Most of the head-bones finely striated, but those of the cranial roof also in part granulated; operculum very high and narrow, interoperculum very small. Dorsal fin arising somewhat behind the highest point of the back, and anal

fin about one-sixth part shorter; both these fins relatively low. Scales resembling those of *P. parvulus*, but the striæ somewhat finer.

Form. & Loc. Lower Coal-Measures (Dalemoor Rake Ironstone); Stanton-by-Dale, Derbyshire.

Not represented in the Collection.

Platysomus rotundus, Hancock & Atthey.

1872. *Platysomus rotundus,* Hancock & Atthey, Ann. Mag. Nat. Hist. [4] vol. ix. p. 252, pl. xvii. fig. 2 (reprinted in Nat. Hist. Trans. Northumb. & Durham, vol. iv. p. 411, pl. xv. fig. 2).

Type. Fish; Newcastle-upon-Tyne Museum.

A very small species, attaining a length of about 0·075. Greatest depth of trunk much exceeding its length from the pectoral arch to the base of the caudal fin; dorsal and ventral margins regularly rounded and deeply convex, thus imparting to the fish a circular form in side view. Several of the head-bones tuberculated; teeth minute. Dorsal and anal fins arising near the middle of the trunk, of moderate height, acuminate in front, and terminating in advance of the caudal pedicle; the fin-rays with distant articulations. Scales relatively narrower than in *P. parvulus*, and more finely striated. (*Hancock & Atthey.*)

Form. & Loc. Coal-Measures: Newsham, Northumberland.

Not represented in the Collection.

Platysomus superbus, Traquair.

1881. *Platysomus superbus,* R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxx. p. 58, pl. vi.

Type. Fish; Geological Survey of Scotland, Edinburgh.

A large species attaining a length of about 0·16. Length of trunk from pectoral arch to base of caudal fin scarcely more than three-quarters as great as its maximum depth; dorsal margin gibbously rounded, almost angulated at its highest point, which is considerably in front of the middle of the back; ventral margin nearly straight in its anterior half, sharply curved upwards posteriorly. Head with opercular apparatus occupying one-third of the total length of the fish to the base of the caudal fin; length of cranial roof with post-temporal bone much greater than the distance between the latter and the origin of the dorsal fin; head and opercular bones ornamented with delicate, close, wavy, sub-parallel striæ, occasionally passing into minute tubercles. Pelvic fins very

remote, relatively large, with closely articulated rays; median fins large, with distinct fulcra, the rays with distant articulations and ornamented by longitudinal striæ. Dorsal and anal fins arising at the dorsal and ventral gibbosities respectively, extending close to the origin of the caudal fin, much elevated in front, the maximum height of the dorsal equalling at least one-third the depth of the trunk at its origin. Scales of flank deep and rhombic, those dorsally and ventrally and towards the end of the caudal region nearly equilateral; ornamentation consisting of very fine parallel striæ, in the direction of the long axis of the principal flank-scales, but somewhat oblique on those above and below.

Form. & Loc. Calciferous Sandstones (Cement-stone Group): Eskdale, Dumfriesshire.

P. 4060. Imperfect typical specimen, wanting paired fins, in counterpart. *Purchased*, 1883.

P. 4061. Small imperfect specimen, with remains of pelvic fins. *Purchased*, 1883.

The following species have also been determined, but there are no examples in the Collection:—

Platysomus circularis, Newberry & Worthen, Pal. Illinois, vol. iv. (1870), p. 347, pl. iv. fig. 2.—Coal-Measures; Mazon Creek, Illinois.

Platysomus orbicularis, Newberry & Worthen, *ibid.* pl. iii. fig. 1 (no description).—Coal-Measures; Illinois.

The so-called *Platysomus fischeri*, Arndt (Bull. Soc. Imp. Nat. Moscou, vol. xxiii. 1850, pt. i. p. 88, pl. i.), is founded upon the tail of a bony (probably physoclystous) Tertiary fish, from the neighbourhood of Simferopol.

Of the remarkable Upper Permian genus *Dorypterus* (E. F. Germar, in Münster's Beitr. Petrefakt. pt. v. 1842, p. 35) there are no examples in the Collection. This fish still requires satisfactory elucidation, but is evidently related to the Platysomatidæ, as indicated by the great development of the azygous fin-supports, which are sometimes at least in part mistaken for dermal structures. So far as the absence of flank-scales is concerned, *Dorypterus* bears the same relation to the typical Platysomatidæ as *Phanerosteon* with respect to the typical Palæoniscidæ. A single species is recognized thus:—

Dorypterus hoffmanni, E. F. Germar, in Münster's Beitr. Petre-

fakt. pt. v. (1842), p. 35, pl. xiv. fig. 4; Hancock & Howse, Quart. Journ. Geol. Soc. vol. xxvi. (1870), p. 623, pls. xlii., xliii., and Nat. Hist. Trans. Northumb. & Durham, vol. iv. (1872), p. 243, pls. ix., x.; K. A. von Zittel, Handb. Palæont. vol. iii. (1887), p. 252, woodc. fig. 265: (?) *Platysomus althausii*, G. von Münster, Beitr. Petrefakt. pt. v. (1842), p. 44, pl. v. fig. 2: (?) *Dorypterus althausi*, K. A. von Zittel, *tom. cit.* p. 251, woodc. fig. 264. [Palæontological Museum, Munich.]—Upper Permian (Kupferschiefer); Province of Saxony and Hesse. Upper Permian (Marl Slate); Durham. [Type specimen in University Museum, Halle; English specimens in Museum of Newcastle-upon-Tyne.]

ADDENDA ET CORRIGENDA.

P. 5. An undescribed variety of *Acanthodes bronni*, from the Lower Permian of Moravia, is recorded as *Acanthodes gracilis*, var. *micracanthus*, A. Rzehak, Verhandl. k.-k. Geol. Reichsanst. 1881, p. 79.

Pp. 9, 10, 11, 13. Since the earlier sheets were printed, Dr. R. H. Traquair has published (Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 481) an outline-figure of *Acanthodes sulcatus* and another of *Acanthodes mitchelli* (this under the generic name of *Mesacanthus*). He also admits (*ibid.* p. 491) the definition of *Acanthodes nitidus* as formulated on p. 9 of the present Catalogue.

P. 26. *Diplacanthus striatus* and *D. longispinus* are also recorded by Traquair (*loc. cit.* p. 482) from Achanarras, Caithness, the second under the name of *Rhadinacanthus longispinus*.

P. 63. In the absence of any information as to the change of form exhibited by Chimæroid teeth during growth, the following specimens may be regarded as not improbably the mandibular teeth of very young individuals of *Ischyodus beaumonti*. At present, however, the determination is doubtful.

41866–67. Three examples of the left mandibular tooth, the largest measuring 0·015 from the symphysial to the post-oral border; Kimmeridge Clay, Weymouth. The symphysial, median, and posterior outer tritors are represented, but the median is very narrow, and the anterior outer tritor is absent or not differentiated from the median. The beak is small; the oral margin is relatively short and faintly wavy, with a slight prominence at the posterior outer tritor; and the post-oral margin is nearly parallel to the symphysis. The oral face is much upturned.

Purchased, 1869.

P. 72. The following tooth, also from the Kimmeridge Clay of Weymouth, seems to represent an undetermined genus allied to *Ischyodus*.

43284. Left mandibular tooth, 0·014 in length, much laterally compressed, and with an external thickening immediately below the oral border. This border is deeply sinuous, and the symphysis is very narrow. Two outer tritors and one beak-tritor occur, each being small, styliform, and laminated; but there is no median tritor. *Purchased*, 1871.

P. 118. To the second group of Ichthyodorulites add the following:—

Compsacanthus carinatus, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. (1883), p. 354, pl. xlvi. fig. 10.—Lower Carboniferous Limestone; Armagh. [*Olim* Enniskillen Coll.: see Introduction.]

Tubulacanthus sulcatus, A. Fritsch, Fauna der Gaskohle, vol. ii. (1889), p. 113, pl. lxxxviii. fig. 14.—Lower Permian; Kounová, Bohemia. [Royal Bohemian Museum.]

Brachiacanthus semiplanus, A. Fritsch, *ibid.* p. 113, pl. lxxxiii. fig. 10.—Ibid. [Ibid.]

Platyacanthus ventricosus, A. Fritsch, *ibid.* p. 113, pl. lxxxvi. fig. 5.—Ibid. [Ibid.]

P. 123. Some genera of the third division of Ichthyodorulites have recently been associated with the Myriacanthidæ by O. Jaekel, and the miscellaneous and indefinable group thus formed is named Trachyacanthidæ (Sitzungsb. Ges. naturf. Freunde, Berlin, 1890, p. 130).

P. 144. The *Gyracanthus* from Burdichouse is now named *G. rectus*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. (1890), p. 417, and said to occur in other localities in S.E. Scotland.

P. 212. *Pterichthys milleri* is now recorded from Achanarras, Caithness, by R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. (1890), p. 483.

P. 248. Under *Phaneropleuron curtum*, Whiteaves, 1889, delete "pl. x. fig. 1": see *Eusthenopteron foordi*, p. 362.

P. 276. It ought to be added that the affinities of the so-called *Cœlacanthus muensteri* were first recognized by Huxley, Mem. Geol. Surv. dec. x. (1861), p. 18.

P. 292. A median ventral plate and some other fragments of *Coccosteus disjectus* are noticed by W. H. Baily, Geol. Surv. Ireland, Expl. Sheets 147, 157 (1861), p. 17, woodc. fig. 4 (in part).

P. 314. The Permian scales named *Phyllolepis fragilis*, A. Fritsch (Sitzungsb. k. böhm. Ges. Wiss. 1875, p. 76), are generically indeterminable.

P. 355. The undefined name *Holoptychius minor*, Agassiz (Poiss. Foss. vol. ii. pt. ii. p. 180), also probably refers to *Rhizodopsis sauroides*.

An undetermined primitive genus and species, apparently piscine, from the Lower Old Red Sandstone of Achanarras, Caithness, is named *Palæospondylus gunni*, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. (1890), p. 485, woodc. fig. 4.

In the recently issued Annual Report of the Secretary for Mines of Victoria, 1889, Prof. F. M'Coy announces the discovery of a Devonian Fish-fauna in the valley of the Broken River, near Mansfield, Victoria. Detailed descriptions are promised in forthcoming "Decades."

ALPHABETICAL INDEX.

[*Note.*—The numbers of pages on which merely incidental references occur are printed in italics.]

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EXPLANATION OF PLATES.

The specimens represented in the Plates are all preserved in the Collection, and bear the register-numbers placed in square brackets. Unless otherwise stated, the drawings are of the natural size.

PLATE I.

Fig. Page

1, 1 *a*. *Lepracanthus colei*, Owen; dorsal fin-spine, lateral aspect, and portion of ornament enlarged four times.—L. Coal-Measures; Lowmoor. [P. 2233.] 115

2. *Acondylacanthus colei*, Davis; transverse section of dorsal fin-spine.—L. Carboniferous Limestone; Armagh. [39167.] 108

3. *Oracanthus* (?) *milleri*, Ag.; spine.—Ibid. [P. 3134.] 137

4. *Cynopodius crenulatus*, Traq.; spine.—Calciferous Sandstone; Pitcorthy, Fife. [42085.] 154

5, 6. *Acanthodes pusillus*, Ag.—L. Old Red Sandstone; Tynet Burn. [35786, P. 1329.] 12

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8. *Ischnacanthus gracilis* (Eg.).—Ibid. [P. 132.] 22

9. *Ganodus oweni*, Ag.; left palatine tooth, oral aspect.—Stonesfield Slate. [P. 3100 b.] 56

10. *Ganodus dentatus*, Eg.; left mandibular tooth, inner aspect, twice nat. size.—Ibid. [P. 614.] 57

11 *a*, *b*. *Ganodus rugulosus*, Eg.; right mandibular tooth, inner and outer aspects.—Ibid. [P. 5152.] 58

12. *Ganodus curvidens*, Eg.; right mandibular tooth, outer aspect.—Ibid. [P. 599.] 58

13. *Ganodus* (?) *bucklandi*, Eg.; right palatine tooth, oral aspect.—Ibid. [P. 3107.] 58

14. *Ischyodus colei* (Ag.); left palatine tooth, oral aspect.—Ibid. [P. 480.] 60

15 *a–c*. *Chimæra pliocenica*, sp. nov.; right palatine tooth, oral, superior, and inner aspects.—Pliocene; Tuscany. [47032.] 91

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Ichthyodorulites, Acanthodii, and Holocephali.

PLATE II.

Fig. Page

1. *Myriacanthus paradoxus*, Ag.; dentition, anterior and oral aspect.—Lower Lias; Lyme Regis. *md.* Mandibular teeth. *pl.* Palatine tooth. *ps.* Presymphysial tooth. *v.* Vomerine tooth. *x.* Supplementary upper tooth or accidental dismemberment of vomerine tooth. [P. 4664.] 47

2, 2 *a*, 2 *b*. Ditto; dentition, superior aspect, transverse section of presymphysial tooth (*a*), and anterior upper tooth (*b*), the last being twice nat. size.—Ibid. *d.* Dermal plates. Other letters as above. [P. 151.] 48

3. Ditto; left mandibular tooth, inner aspect.—Ibid. [P. 477.] 46

4, 4 *a*, 4 *b*. *Myriacanthus granulatus*, Ag.; dentition, anterior and oral aspect, and presymphysial tooth in side view (*a*) and transverse section (*b*), the last three times nat. size.—Ibid. *t.* Dermal tubercles. Other letters as above. [P. 4575.] 49

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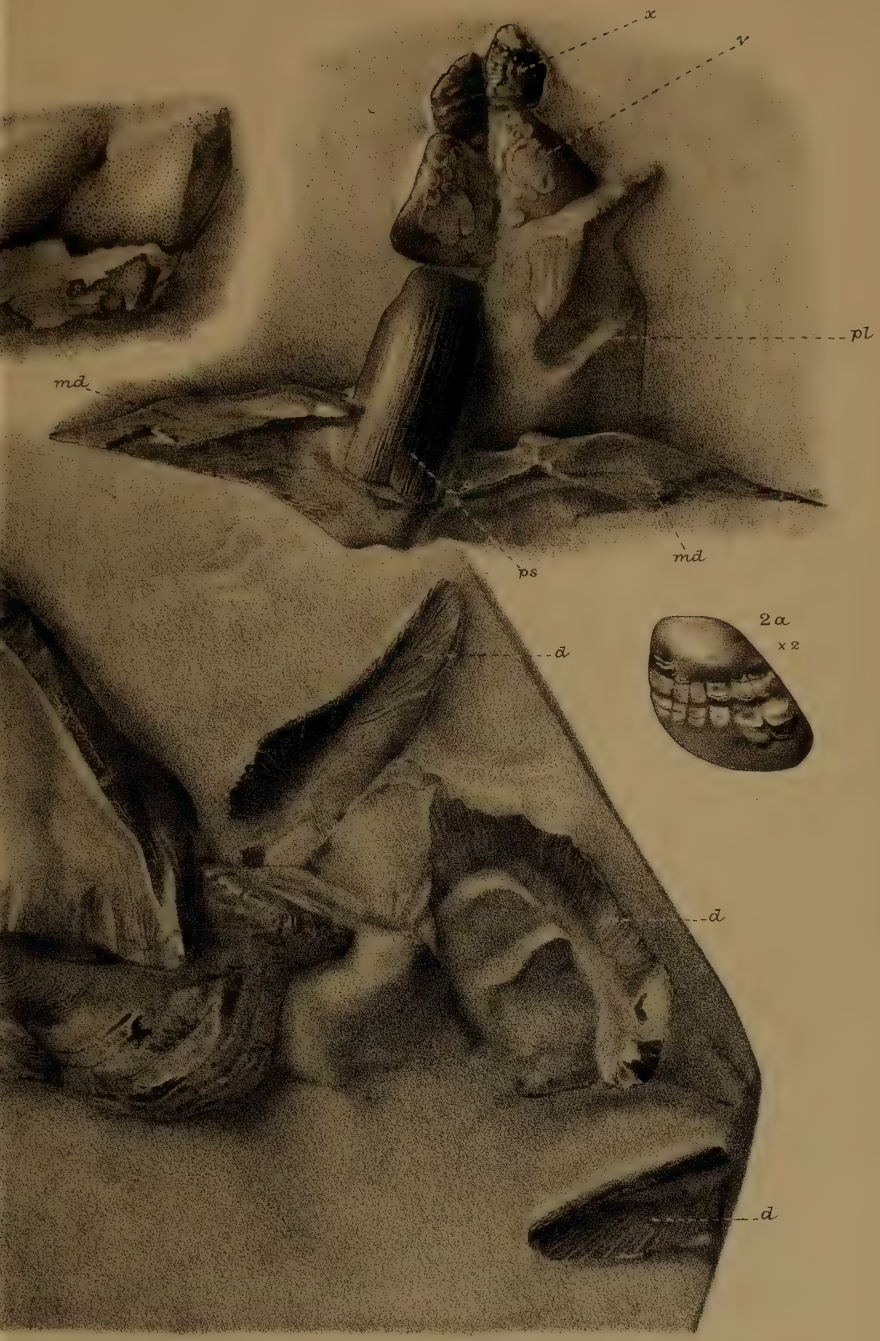

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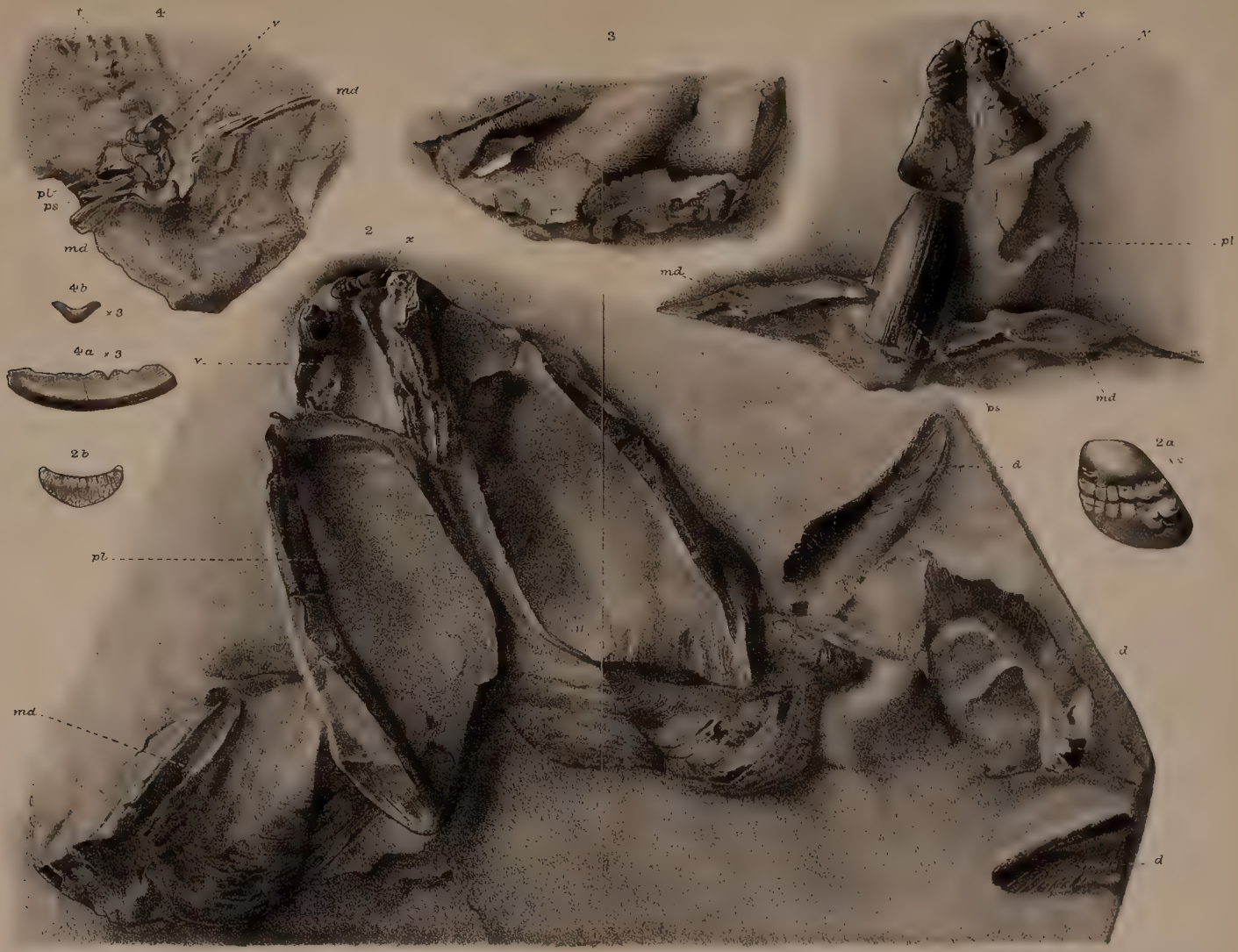
rognathodus).

Plate II.



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Myriacanthus (Prognathodus).

PLATE III.

Fig. Page

1. *Diplacanthus longispinus*, Ag.; ventro-lateral aspect of fish.—L. Old Red Sandstone; Gamrie. *a*. Anal fin-spine. d_1, d_2. Dorsal fin-spines. *i*. Intermediate pair of spines. *pct*. Pectoral fin-spines. *plv*. Pelvic fin-spines. *x*. Pectoral arch. [P. 4041.] 27

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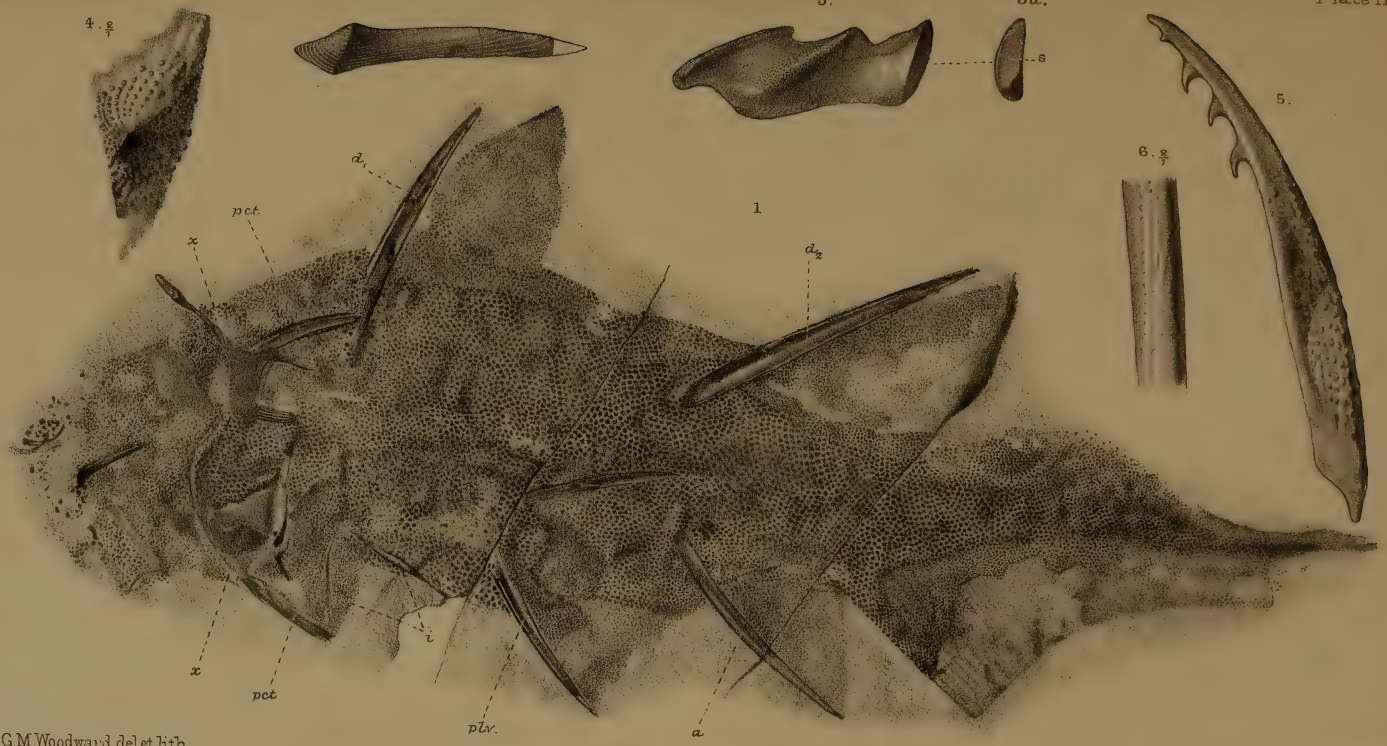
3, 3 *a*. *Myriacanthus granulatus*, Ag.; left mandibular tooth, inner and symphysial aspects.—Ibid. *s*. Bevelled symphysial surface. [P. 3099.] 50

4. Ditto; dermal plate, outer aspect, twice nat. size.—Ibid. [P. 1158.] 50

5. *Myriacanthus*, sp. (?); dorsal fin-spine.—Ibid. [P. 2850.] 51

6. *Heteracanthus heterogyrus* (Ag.); fragment of dermal spine, lateral aspect, twice nat. size.—Devonian; Russia. [P. 2248.] 125



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Acanthodii and Chimæroidei.

PLATE IV.

Fig. Page

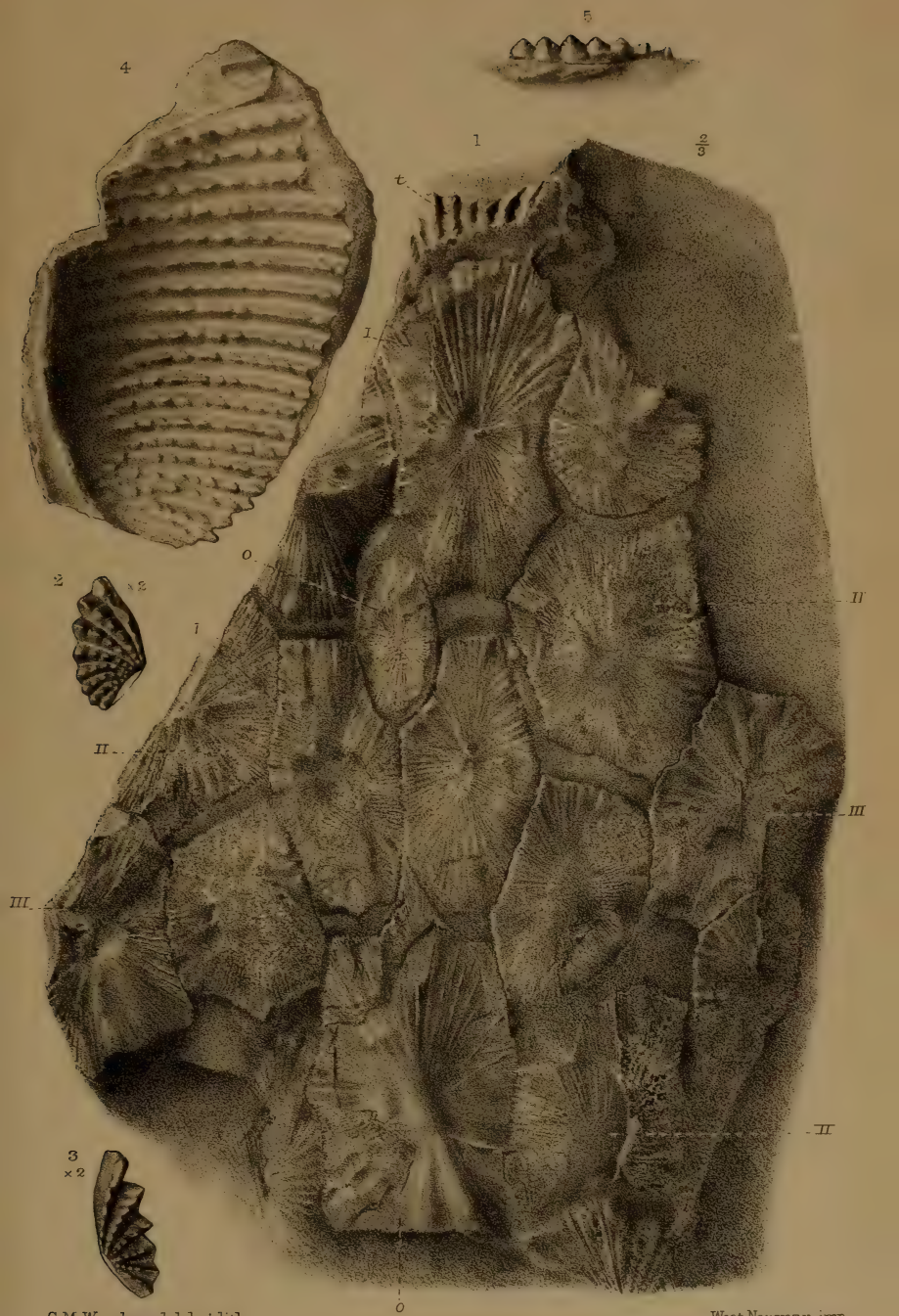
1. *Ctenodus cristatus*, Ag.; bones of cranial roof, two-thirds nat. size.—Coal-Measures; Clanway, North Staffordshire. *t*. Dental plate. 0. Median azygous series. I. Inner paired series. II. Second paired series. III. Third paired series. [P. 5031.] 252

2. *Sagenodus inæqualis*, Owen; right upper dental plate of young, twice nat. size.—Coal-Measures; Newsham. [P. 3381.] 259

3. Ditto; right lower dental plate, twice nat. size.—Coal-Measures; Longton. [P. 3381 a.] 259

4. *Ctenodus murchisoni*, Ward; left upper dental plate.—Upper Coal-Measures; Leebotwood. [P. 518.] 255

5. *Uronemus splendens*, Traq.; lower marginal teeth.—Middle Carboniferous Limestone; Borough Lee. [P. 5986.] 250



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Carboniferous Dipnoi.

PLATE V.

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1. *Asterolepis maxima* (Ag.); anterior median dorsal plate, visceral aspect, one-third nat. size, showing overlapping facettes (*ov.*).—Upper Old Red Sandstone; Nairn. [38710.] 206

2. *Pterichthys milleri*, Ag.; cranial shield, visceral aspect.—Lower Old Red Sandstone; Lethen Bar. *l.occ.* Lateral occipital. *m.occ.* Median occipital. *o.* Orbital (? sclerotic) plate. *p.* Pineal ("os dubium"). *pt.m.* Post-median. [49187.] 213

3. Ditto; dorsal aspect.—Ibid. *a.d.l.* Anterior dorso-lateral. *a.m.d.* Anterior median dorsal. *a.v.l.* Anterior ventro-lateral. *d.* Dorsal fin. *e.l.* Extralateral (operculum). *f.* Caudal ridge-scales. *mn.* Mental. *p.d.l.* Posterior dorso-lateral. *p.v.l.* Posterior ventro-lateral. [50109.] 213

4. Ditto; ventral aspect.—Ibid. *ar.* Articular. *mv.* Median ventral. Other letters as above. [50110.] 214

5. Ditto; trunk and tail, lateral aspect.—Lower Old Red Sandstone; Gamrie. *p.m.d.* Posterior median dorsal. Other letters as above. [P. 4036.] 215

6. Ditto; operculum or extralateral plate, visceral aspect.—Lower Old Red Sandstone; Tynet Burn. [35981.] 215

7. Ditto; anterior median dorsal plate, outer aspect, showing overlapped postero-lateral border.—Ibid. [35980.] 215

8. *Pterichthys testudinarius*, Ag.; dorsal aspect of head, ventral aspect of trunk.—Lower Old Red Sandstone; Lethen Bar. *l.* Lateral. *pm.* Premedian. Other letters as above. [49190.] 216

9. *Pterichthys productus*, Ag.; ventral aspect of trunk.—Ibid. Lettering as above. [P. 534.] 217

10. *Pterichthys oblongus*, Ag.; distal portion of appendage.—Ibid. *a.* Anconeal. *c.* Central. *m.* Marginal. *t.* Terminal. [39174.] 220

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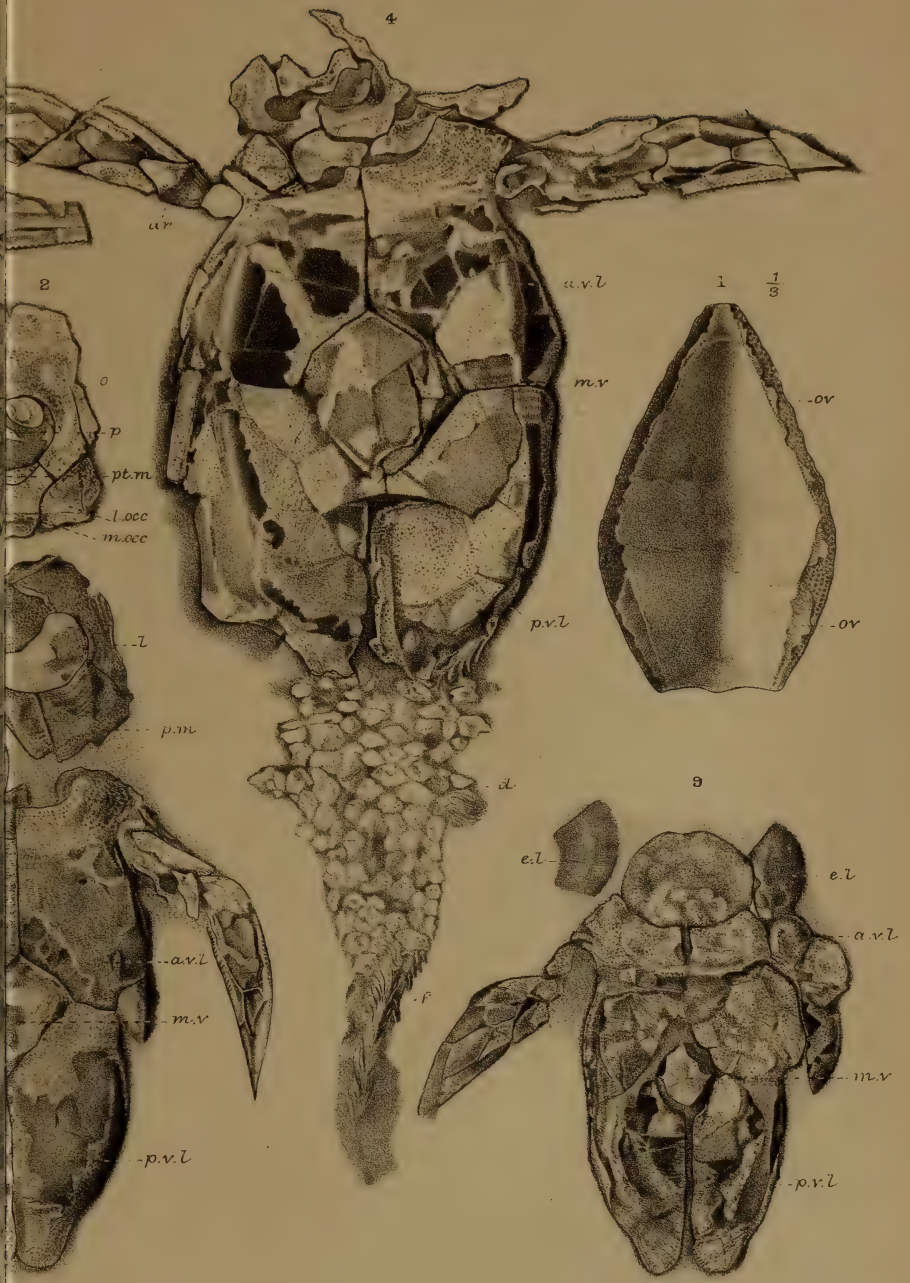
Asterolepis



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d Pterichthys.

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Asterolepis and Pterichthys.

PLATE VI.

Fig. Page

1. *Pterichthys testudinarius*, Ag.; dorsal (in part visceral) aspect of trunk and tail.—Lower Old Red Sandstone; Lethen Bar. *a.v.l.* Anterior ventro-lateral. *d.* Dorsal fin. *f.* Caudal ridge-scales. *m.v.* Median ventral. *p.v.l.* Posterior ventro-lateral. [P. 5053.] 217

2. *Pterichthys productus*, Ag.; ventral aspect.—Ibid. *e.l.* Extralateral (operculum). Other letters as above. [50111.] 218

3. *Pterichthys oblongus*, Ag.; ventral aspect.—Lower Old Red Sandstone; Gamrie. *a.m.d.* Anterior median dorsal. *x.* Caudal fin. Other letters as above. [P. 664 a.] 220

4. Ditto; ventral aspect.—Lower Old Red Sandstone; Lethen Bar. *a.* Anconeal. *c.* Central. *l.* Lateral. *m.* Marginal. *p.* Pineal ("os dubium"). *p.m.* Premedian. *t.* Terminal. Other letters as above. [50107.] 221

5. *Bothriolepis major* (Ag.); cranial shield, dorsal aspect.—Upper Old Red Sandstone; Alves, near Elgin. *l.occ.* Lateral occipital. *m.occ.* Median occipital. *pt.m.* Postmedian. Other letters as above. [38717.] 227

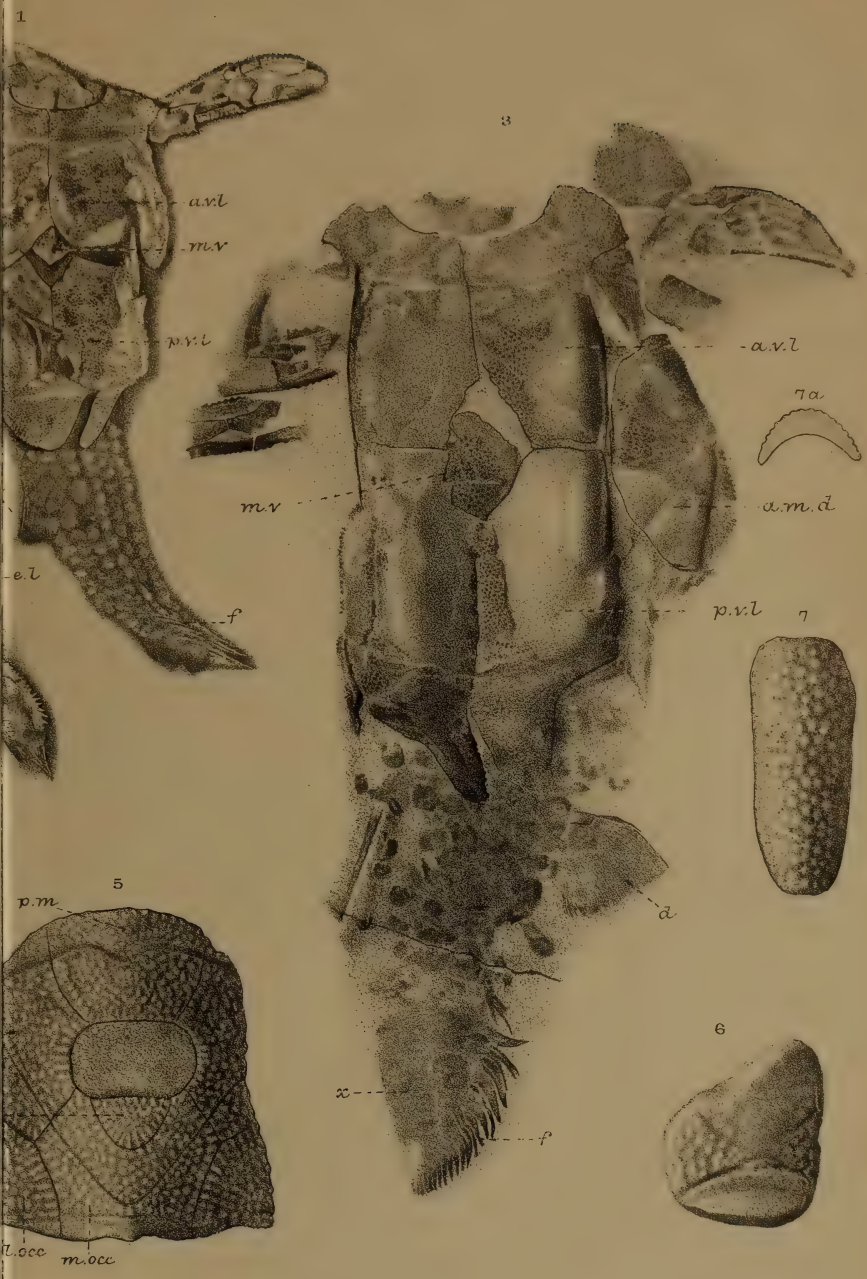
6. Ditto; imperfect abraded median occipital plate, outer aspect.—Upper Old Red Sandstone; Scat Craig, near Elgin. [35995 a.] 227

7, 7*a*, 8, 8*a*. Ditto; two marginal plates of appendage, the first edge-view and in transverse section, the second side-view and in transverse section.—Ibid. [35995 c.] 227

9. *Bothriolepis hydrophila* (Ag.); left ventro-lateral and proximal portion of appendage, ventral aspect.—Upper Old Red Sandstone; Dura Den. *ar.* Articular plate of appendage. *r.* Inner transverse ridge of anterior ventro-lateral, exposed by removal of substance of this plate. *ov.* Overlapped inner border of the left ventro-lateral. [26121 a.] 231

G.M.Woodward del. et lith.

Pterichthys ar



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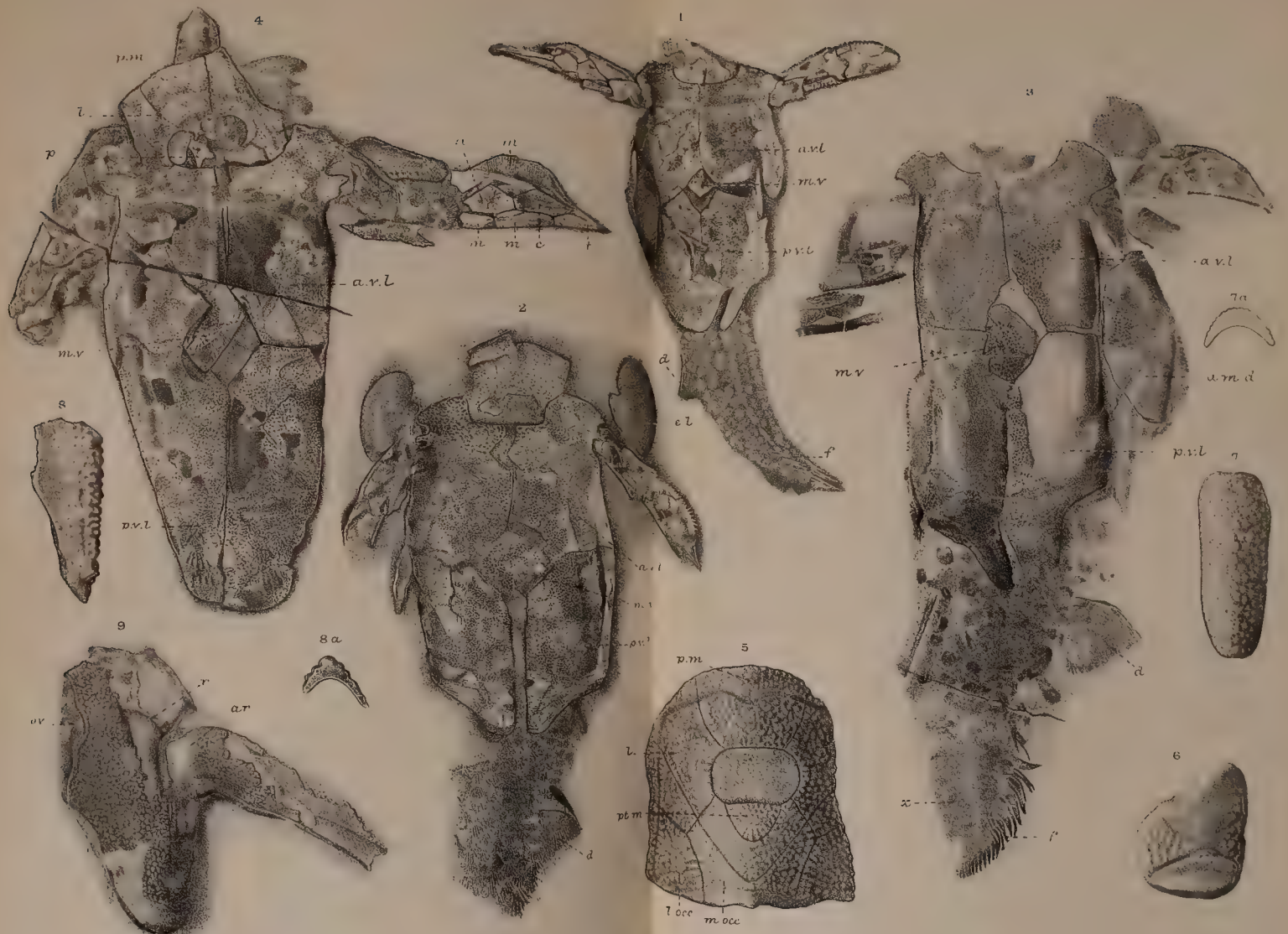
Bothriolepis.



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Pterichthys and Bothriolepis.

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PLATE VII.

Fig. Page

1. *Coccosteus decipiens*, Ag.; cranial shield, dorsal aspect.—Lower Old Red Sandstone; Tynet Burn. *c.* Central. *e.* Ethmoid. *l.occ.* Lateral occipital. *m.* Marginal. *m. occ.* Median occipital. *orb.* Orbit. *p.* Pineal. *p.o.* Preorbital. *pt.o.* Postorbital. *scl.?* Sclerotic. [44586.] 289

2. Ditto; abdominal region, lateral aspect.—Ibid. b^1, b^2. Double series of basal cartilages of dorsal fin. *d.* Median dorsal plate. *f.* Foramina or pittings in pelvic basipterygium. *h.* Hæmal arches and spines. *l.l.* Calcification of lateral line. *n.* Neural arches and spines. *not.* Vacant space occupied by notochord. *p.v.l.* Posterior ventrolateral plate. *plv.* Pelvic basipterygium. *r.* Cartilaginous rays of pelvic fin. *x.* Thin vertical calcified plate at hinder end of abdominal region. [43617.] 288

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Coccosteus.

PLATE VIII.

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1, 2. *Coccosteus disjectus*, sp. nov.; associated median ventral plates, external aspect, the anterior extremity of the second inadvertently turned downwards.—Upper Old Red Sandstone; Kiltorcan. [43039.] 292

3. Ditto; right posterior ventro-lateral plate, visceral aspect.—Ibid. [41901.] 292

4. Ditto; portion of superficial ornamentation, twice nat. size.—Ibid. [43039 a.] 292

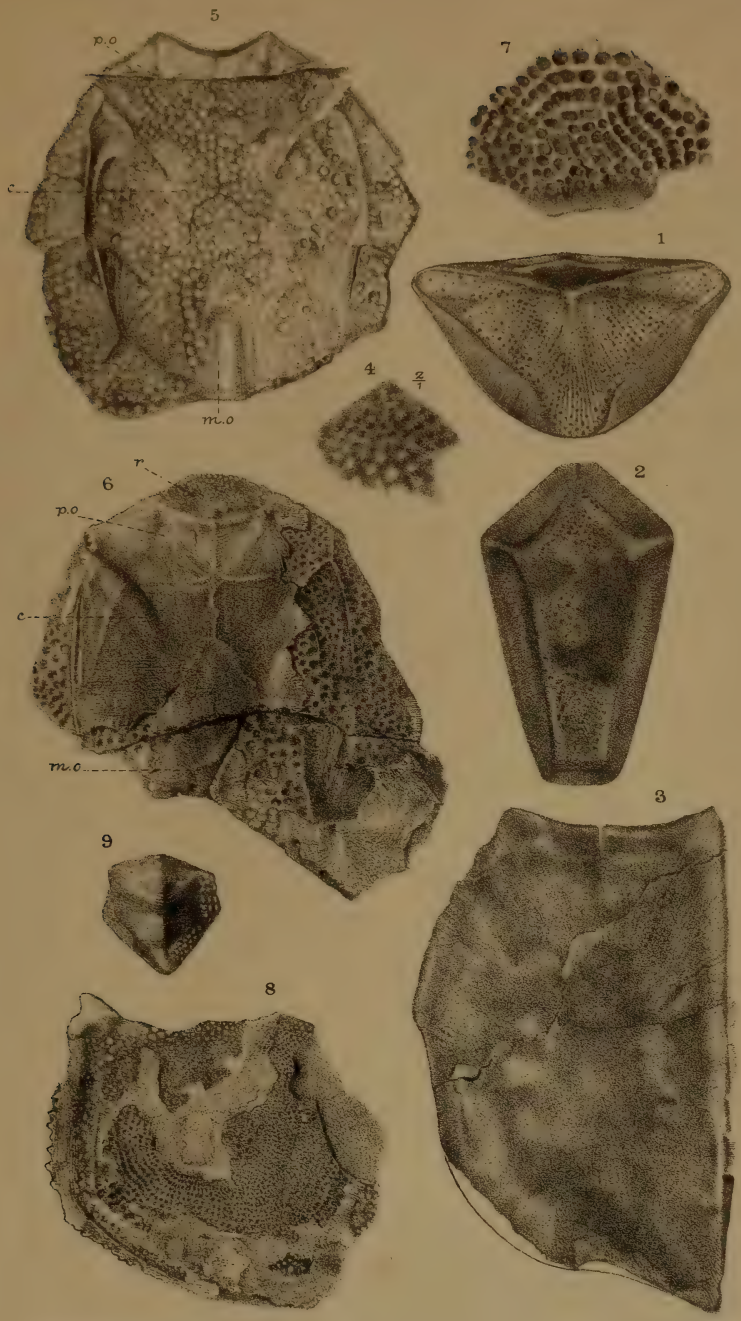
5. *Phlyctænaspis anglica*, Traq.; impression of dorsal cranial shield, wanting rostral plate.—Lower Old Red Sandstone; Cradley. *c.* Central. *m.o.* Median occipital. *p.o.* Preorbital. [42147.] 297

6. Ditto; dorsal cranial shield, partly visceral aspect, partly impression of outer surface.—Lower Old Red Sandstone; Heightington. *r.* Rostral plate. Other letters as above. [37388.] 297

7. Ditto; impression of external tubercular ornament of undetermined plate.—Ibid. [38032 b.] 298

8. Ditto; (?) imperfect ventro-lateral plate.—Ibid. [37388 b.] 298

9. Undetermined ridge-plate, outer aspect.—Lower Old Red Sandstone; Cradley. [P. 5274.] 298



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Coccosteidæ.

PLATE IX.

Fig. Page

1. *Pteraspis rostrata* (Ag.); transverse section of dorsal shield, in outline.—Lower Old Red Sandstone; Goldtops, Newport, Monmouthshire. [P. 5037.] 162

2, 2 *a*. Ditto?; ventral shield ("*Scaphaspis lewisi*"), inferior and lateral aspects, two-thirds nat. size.—Lower Old Red Sandstone; Kentchurch, Herefordshire. [P. 5861.] 164

3. *Cyathaspis banksi* (Huxl. & Salt.); portion of dorsal shield, outer aspect, twice nat. size, showing ornament.—Upper Silurian Bone-bed; Martel, near Ledbury. [P. 3241.] 172

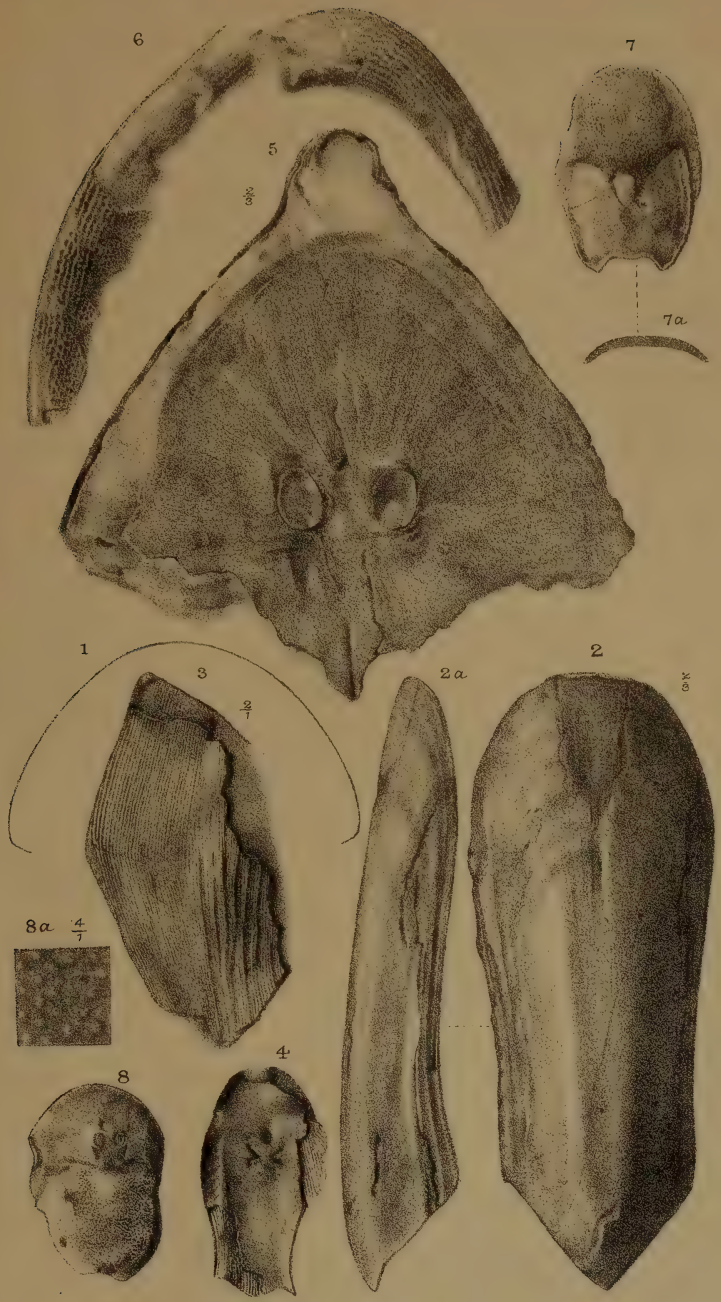
4. *Cyathaspis macculloughi*, sp. nov.; dorsal shield, visceral aspect and partly an impression of outer aspect.—Lower Old Red Sandstone; Bodenham. [P. 4797.] 172

5. *Cephalaspis campbelltonensis*, Whiteaves; dorsal shield, imperfect posteriorly, shown as impression of visceral aspect, two-thirds nat. size.—Lower Devonian; Campbellton, New Brunswick. [P. 5479.] 191

6. *Cephalaspis murchisoni*, Eg.; imperfect inferior rim of shield.—Lower Old Red Sandstone Passage Beds; Ledbury. [P. 6111.] 190

7, 7 *a*. *Didymaspis grindrodi*, Lank.; ventral shield, visceral aspect, and transverse section of matrix lying between dorsal and ventral shields.—Lower Old Red Sandstone; Bush Pitch, Ledbury. [P. 5043.] 200

8, 8 *a*. Ditto; imperfect dorsal shield, with portion of tubercular ornament enlarged four times.—Ibid. [P. 5313.] 200



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Pteraspidæ and Cephalaspidæ.

PLATE X.

Fig. Page

1. *Cephalaspis murchisoni*, Eg., and (A) *Auchenaspis egertoni*, Lank.; group of several individuals.—Lower Old Red Sandstone Passage Beds; Ledbury. I.–III. Principal specimens mentioned in description. *x*. Operculum. [P. 6023.] 189

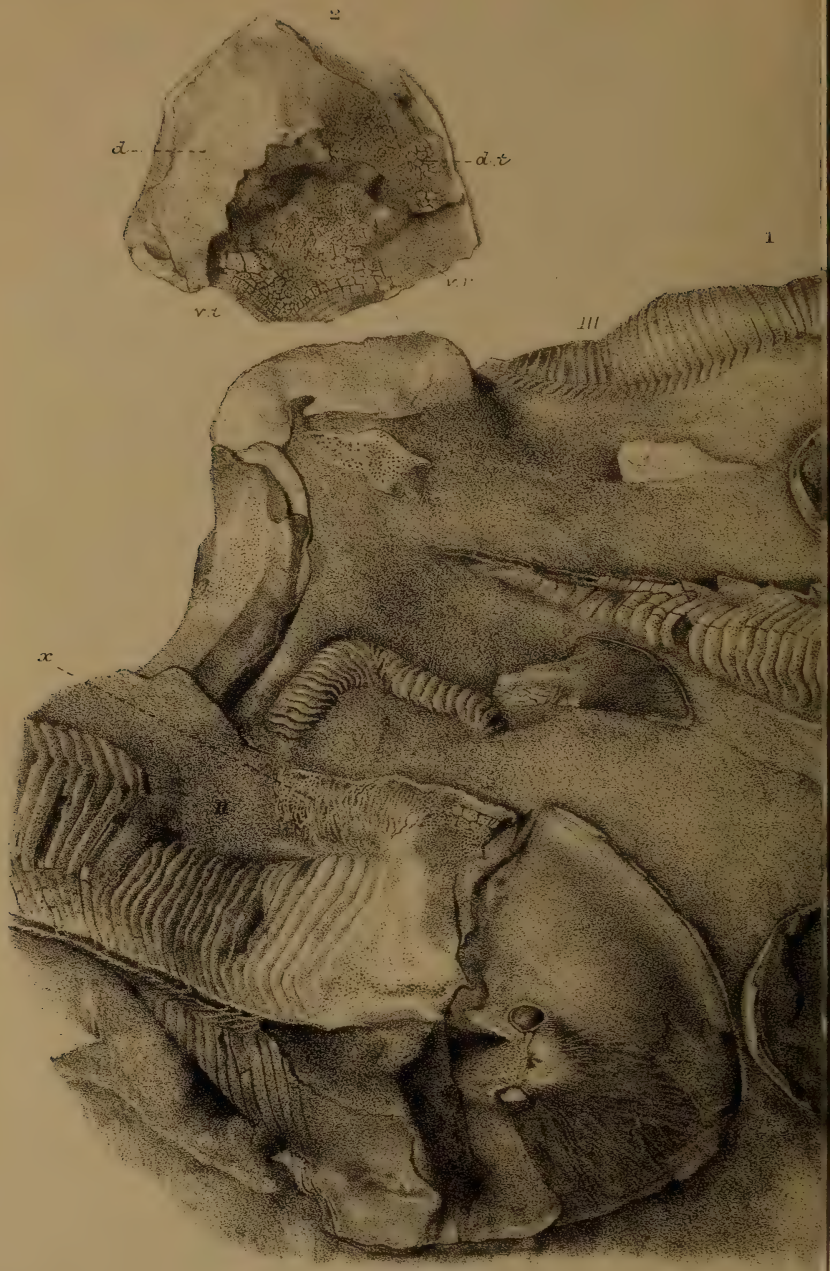
2. *Cephalaspis murchisoni*, Eg.; imperfect shield showing ventral dermal plates, visceral aspect.—Ibid. *d*. Internal cast of dorsal shield. *d.t.* Tesseræ of dorsal shield. *v.r.* Inferior rim of shield. *v.t.* Tessellated dermal plates of ventral surface. [P. 6108.] 189

3. Ditto; portion of tubercular ornament of shield, four times nat. size.—Ibid. [P. 6109.] 190

4. Ditto; portion of squamation of trunk.—Ibid. *d.l.* Dorso-lateral scales. *l.* Inferior lateral scales. *v.* Ventral scales, visceral aspect. [P. 6260.] 189

5. *Auchenaspis egertoni*, Lank.; dorsal aspect.—Ibid. [Specimen marked A in fig. 1.] [P. 6023.] 197

6. Ditto; external aspect of dorsal shield, showing tubercles.—Ibid. [P. 6112.] 197



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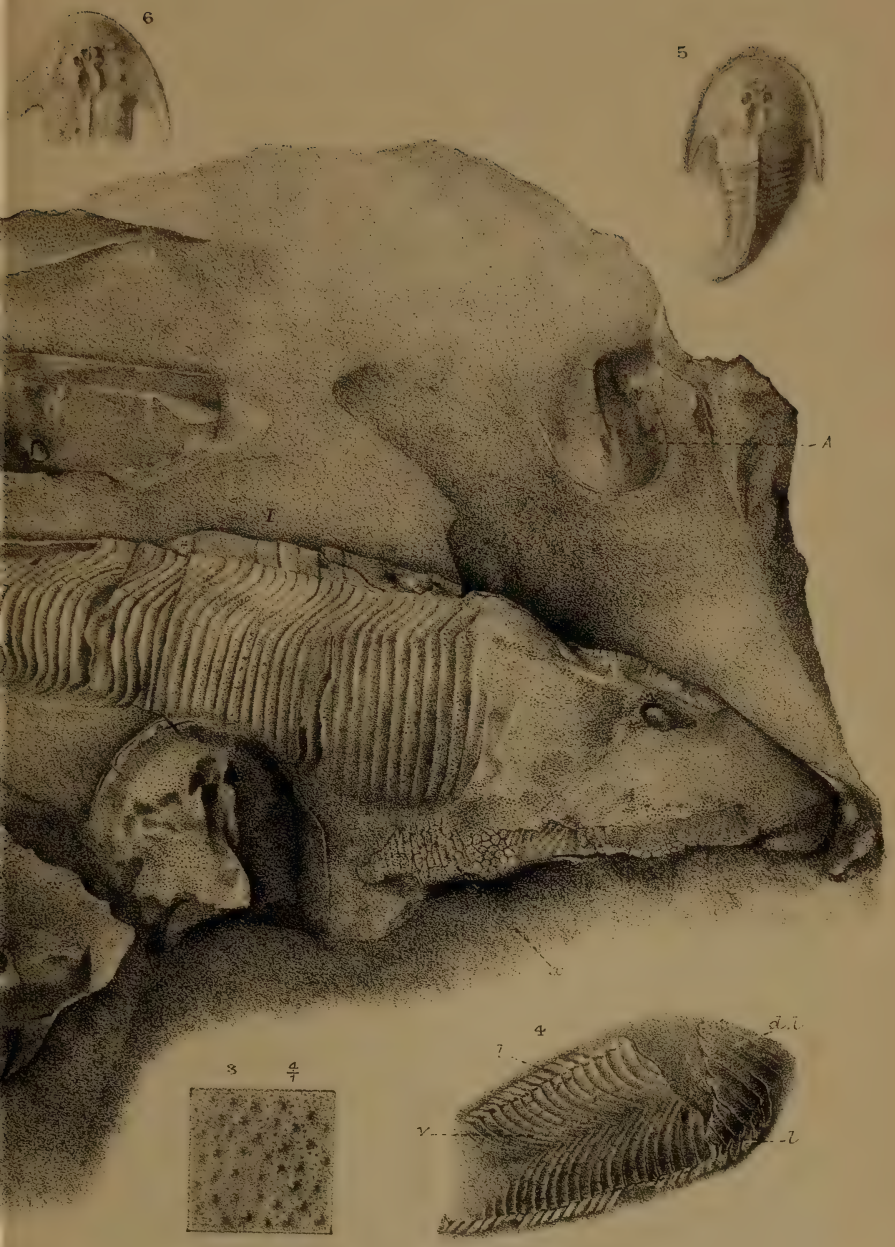
Cephalaspis



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...d Auchenaspis.

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Cephalaspis and Auchenaspis.

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PLATE XI.

Fig. Page

1 *a–d.* *Holoptychius flemingi*, Ag.; scales, external aspect, two from the abdominal, and two from the caudal region.—Upper Old Red Sandstone; Dura Den. [**26120 a.**] 329

2. *Holoptychius* (*Glyptolepis*) *leptopterus*, Ag.; lateral aspect.—Lower Old Red Sandstone; Gamrie. [**P. 4042.**] 334

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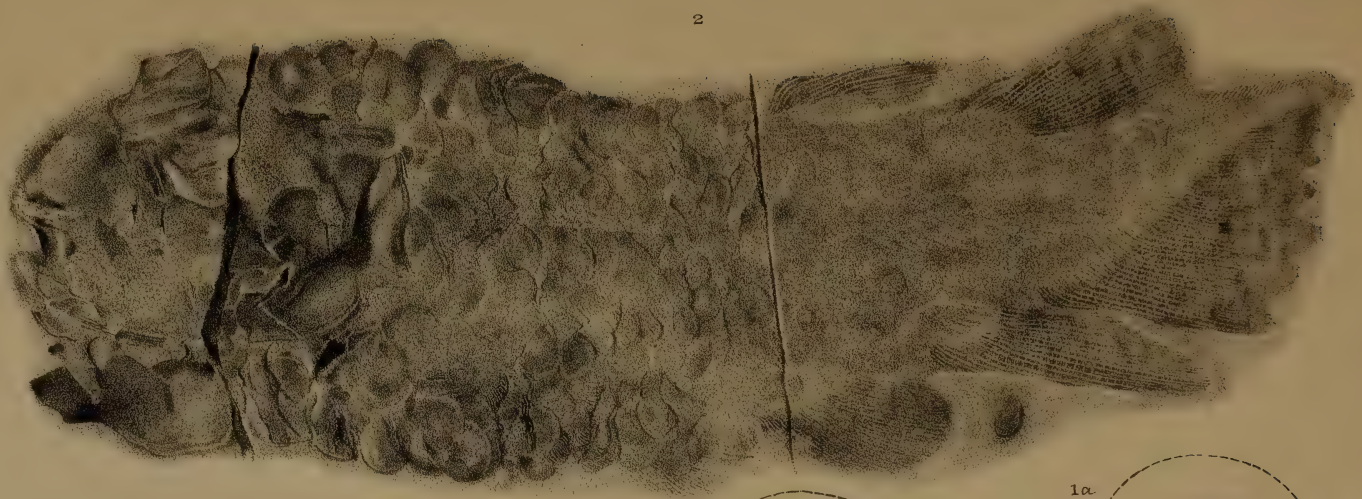

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1c

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Holoptychius and Glyptolepis.

PLATE XII.

Fig. Page

1. *Rhizodus hibberti* (Ag. & Hibb.); left mandibular ramus, external aspect, one-third nat. size.—Lower Carboniferous Limestone; Gilmerton. *ag.* Angular. *d.* Dentary. *inf.d.* Infradentaries. [P. 3317.] 344

2. Ditto; lower laniary tooth, lateral aspect.—Possil Blackband (Middle Carboniferous Limestone); Airdrie. [P. 4800.] 344

3. Ditto; right clavicle, visceral aspect, one-third nat. size.—Gilmerton. [21222 f.] 345

4. Ditto; right infraclavicle, visceral aspect, one-third nat. size.—Ibid. [24841.] 345

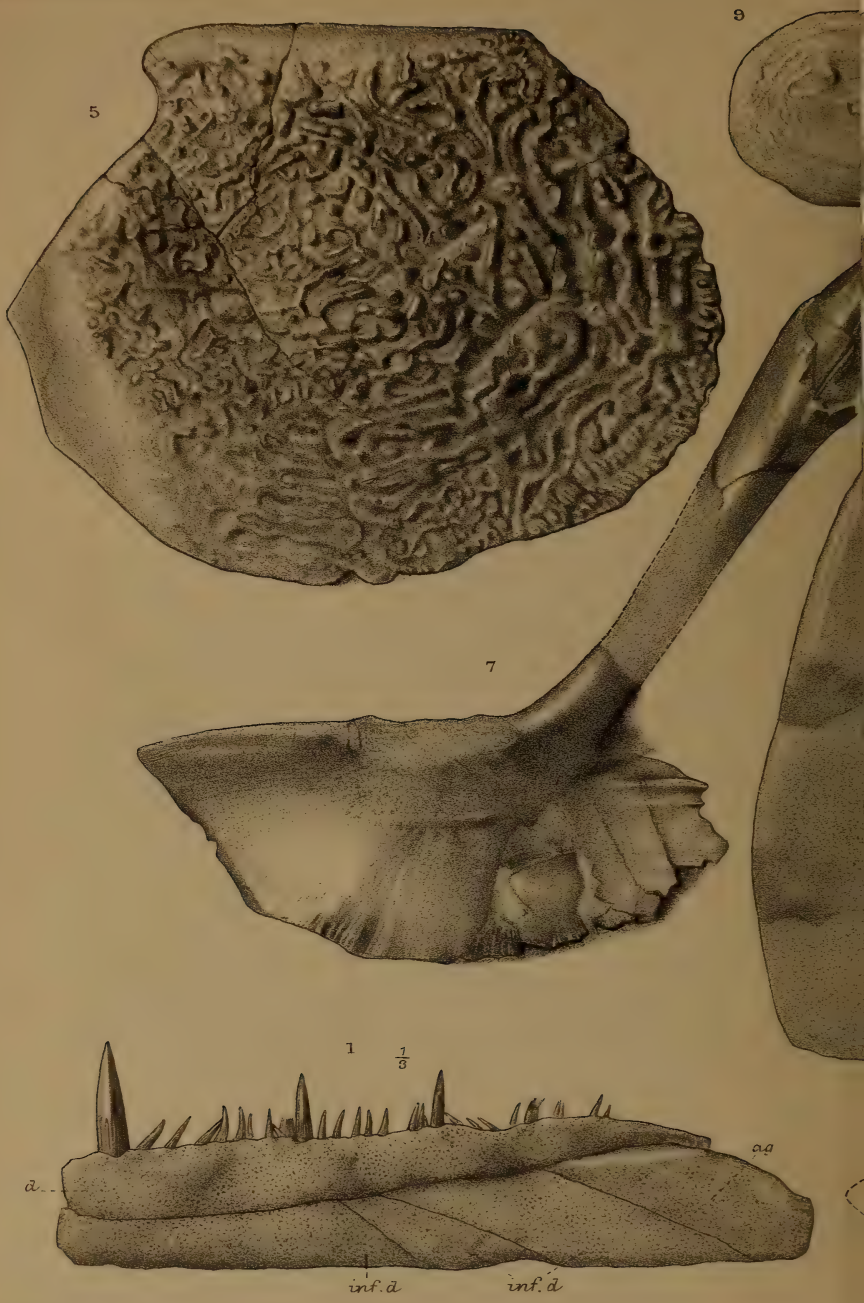
5. *Rhizodus ornatus*, Traq.; operculum, external aspect.—Ibid. [P. 3321.] 347

6. Ditto; right clavicle, imperfect superiorly, external aspect.—Ibid. [P. 3345.] 347

7. Ditto; right infraclavicle, visceral aspect.—Ibid. [P. 3321.] 347

8. Ditto; scales, external aspect.—Ibid. [P. 3345.] 347

9. Ditto; scale, inner aspect.—Ibid. [36914.] 348



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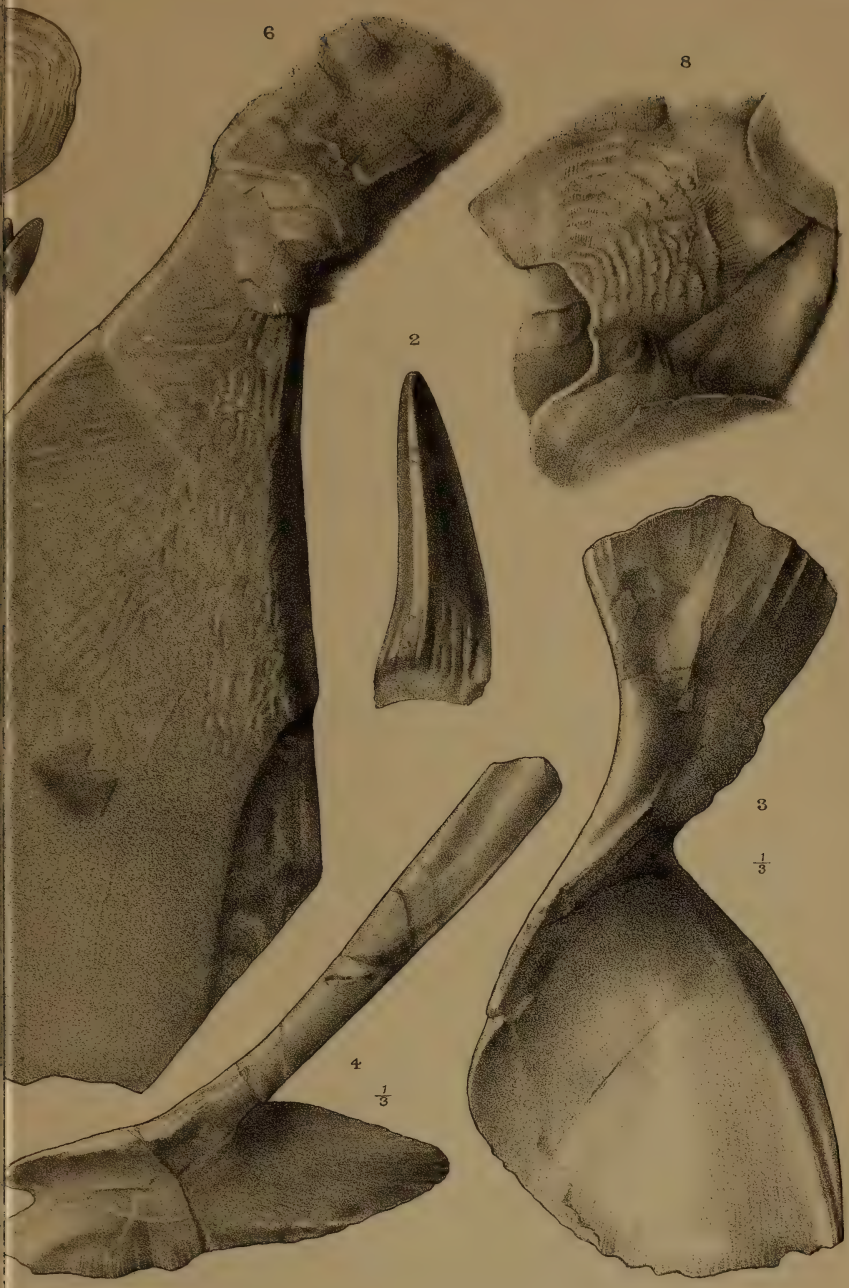
Rhiz



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Rhizodus

West, Newman imp

PLATE XIII.

Fig. Page

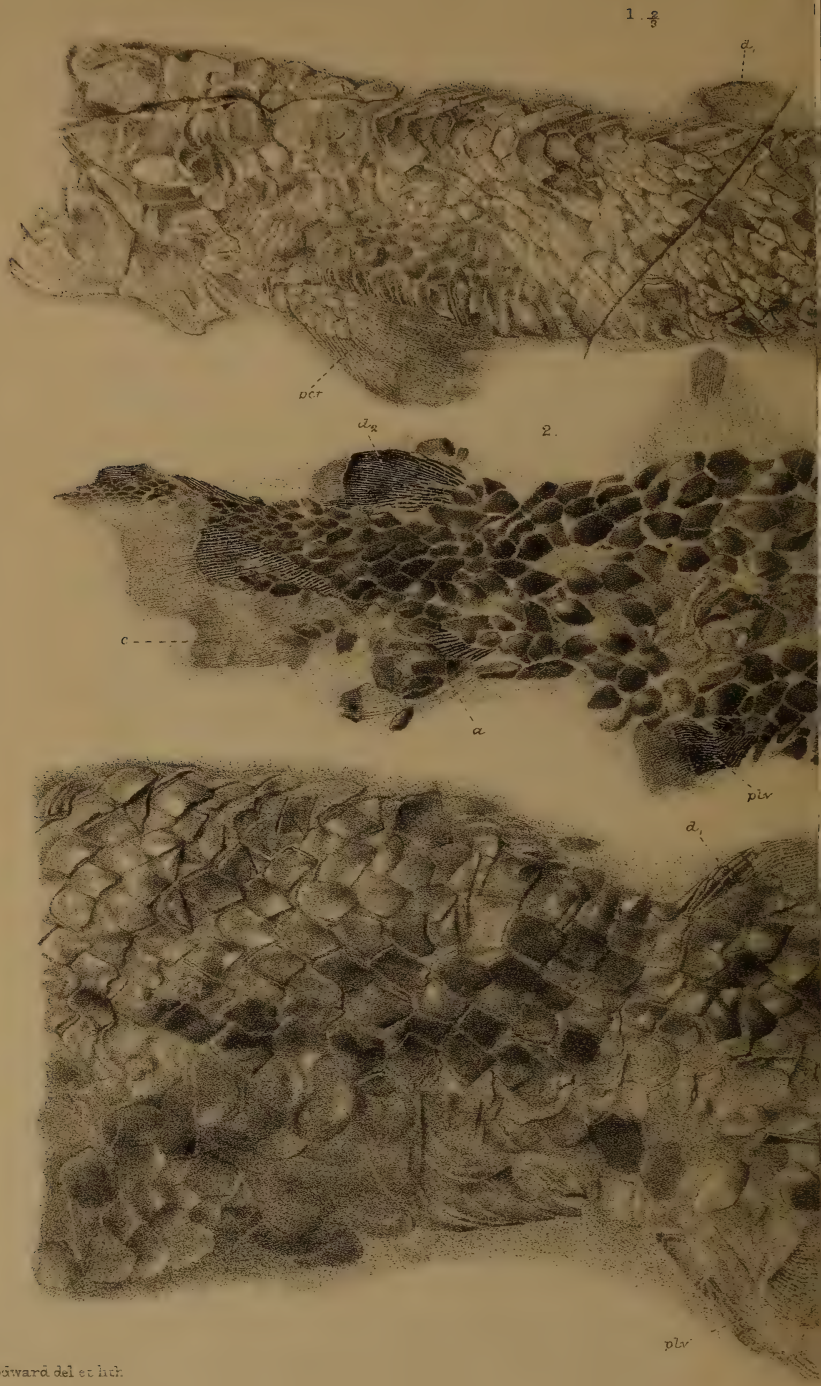
1. *Osteolepis macrolepidotus*, Ag.; lateral aspect, two-thirds nat. size.—Lower Old Red Sandstone; Lethen Bar. *a*. Anal fin. *c*. Caudal fin. d_1, d_2. Dorsal fins. *pct*. Pectoral fin. *plv*. Pelvic fin. [**49181.**] 370

2. *Thursius pholidotus*, Traq.; hinder portion of trunk, lateral aspect.—Lower Old Red Sandstone; Caithness. Lettering as above. [**41361.**] 374

3. Ditto; ditto.—Lower Old Red Sandstone; Thurso. Lettering as above. [**33140.**] 375

4. *Megalichthys hibberti*, Ag.; hinder portion of trunk, lateral aspect.—Coal-Measures; Airdrie. *v*. Vertebral rings. Other lettering as above. [**38007.**] 383

5. *Megalichthys coccolepis*, Young; portion of ornament, five times nat. size.—Coal-Measures; Newsham. [**P. 5494.**] 384



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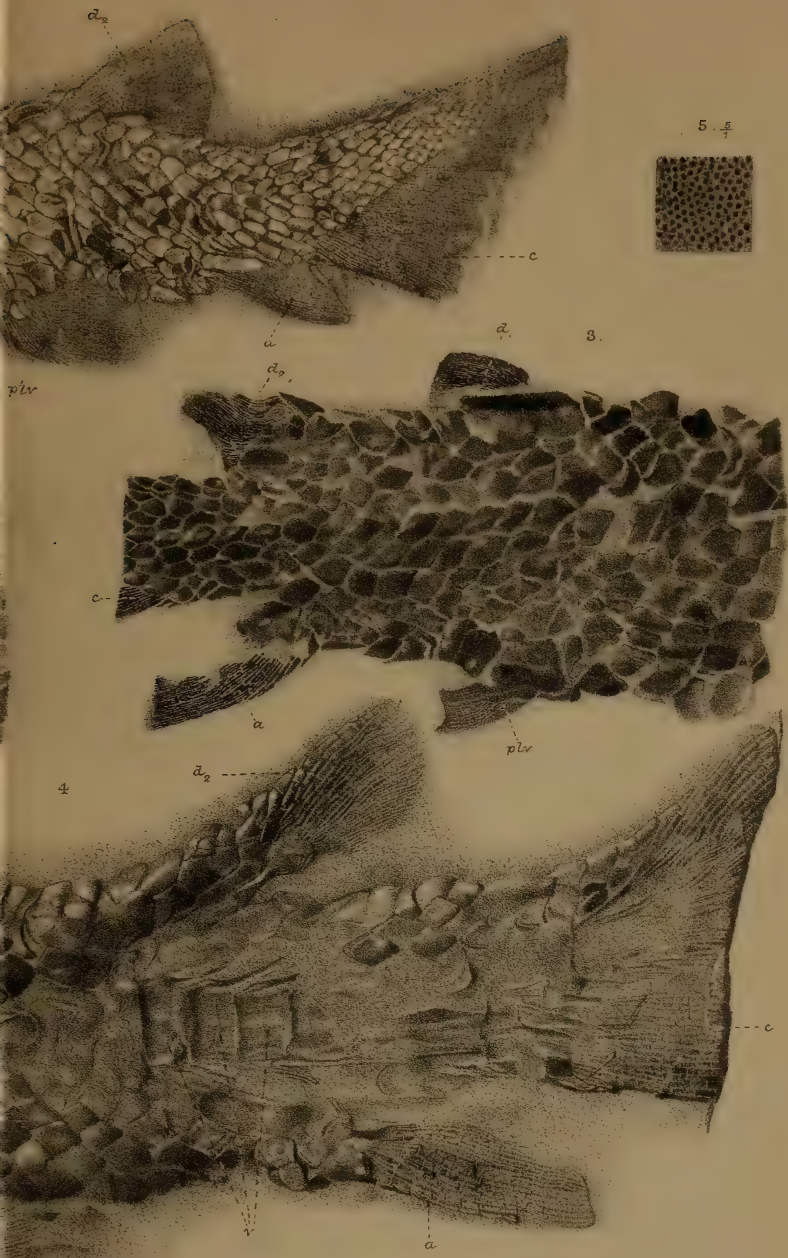

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Osteolepidæ.

PLATE XIV.

Fig. Page

1, 1 *a*, 1 *b*. *Cœlacanthus huxleyi*, Traq.; lateral aspect, with scales (*a*) and jugular plate (*b*) enlarged three times.—Calciferous Sandstone; Eskdale. [**P. 4080 a.**] 407

2, 2 *a*. *Cœlacanthus elegans*, Newb.; lateral aspect, and impression of scales (*a*) enlarged three times.—Culm-Measures; Instow. *d*. Mandible. *ju*. Jugular plate. *op*. Operculum. *x*. Cheek-plates. [**P. 5379, P. 6286.**] 405

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Cœlacanthidæ.

PLATE XV.

Fig. Page

1. *Onychodus anglicus*, A. S. Woodw.; section of presymphysial bone, with bases of teeth, twice nat. size.—Lower Old Red Sandstone; Bush Pitch, Ledbury. [P. 6252.] 393

2. *Amblypterus traquairi*, sp. nov.; lateral aspect, nearly three-quarters nat. size.—Lower Permian; Lebach. [P. 994, P. 3457.] 439

3. *Acrolepis wilsoni*, Traq.; scale, outer aspect, twice nat. size.—Yoredale Rocks; Belper. [P. 5329.] 507

4. *Acrolepis* (?) *digitata*, sp. nov.; scale, outer aspect, twice nat. size.—Karoo Formation; Graaf Reinet District, Cape Colony. [47080.] 509

5. *Platysomus gibbosus* (Blainv.); portion of small trunk, lateral aspect, showing pelvic fins.—Marl Slate; Middleridge. [P. 1606.] 545

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1. Onychodus. 2-4 Palæoniscidæ. 5. Platysomus.

PLATE XVI.

Fig. Page

1. *Strepsodus sauroides* (Binney); scale, outer aspect, two-thirds nat. size.—English Coal-Measures. [40533.] 351

2. Ditto; scale, inner aspect, two-thirds nat. size.—Coal-Measures; Longton. [36478.] 351

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4. *Sauripterus anglicus*, sp. nov.; imperfect laniary tooth.—Upper Old Red Sandstone; Farlow. [P. 200.] 366

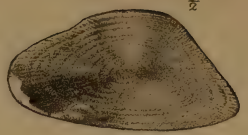
5. Ditto; scale, outer aspect, two-thirds nat. size.—Ibid. [P.200 b.] 366

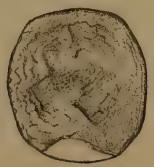
6. Ditto; scale.—Ibid. [P. 200.] 366

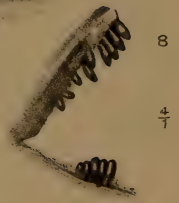
7. *Gonatodus parvidens*, Traq.; lateral aspect.—Carboniferous Limestone Series; Wallyford. [P. 3443.] 436

8. *Gonatodus macrolepis*, Traq.; jaws with teeth, four times nat. size.—Carboniferous Limestone Series; Gilmerton. [P. 843.] 435

9. *Cryphiolepis striata*, Traq.; scale, outer aspect, three times nat. size.—Carboniferous Limestone (Edge Coal Series); Borough Lee. [P. 4116.] 523







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